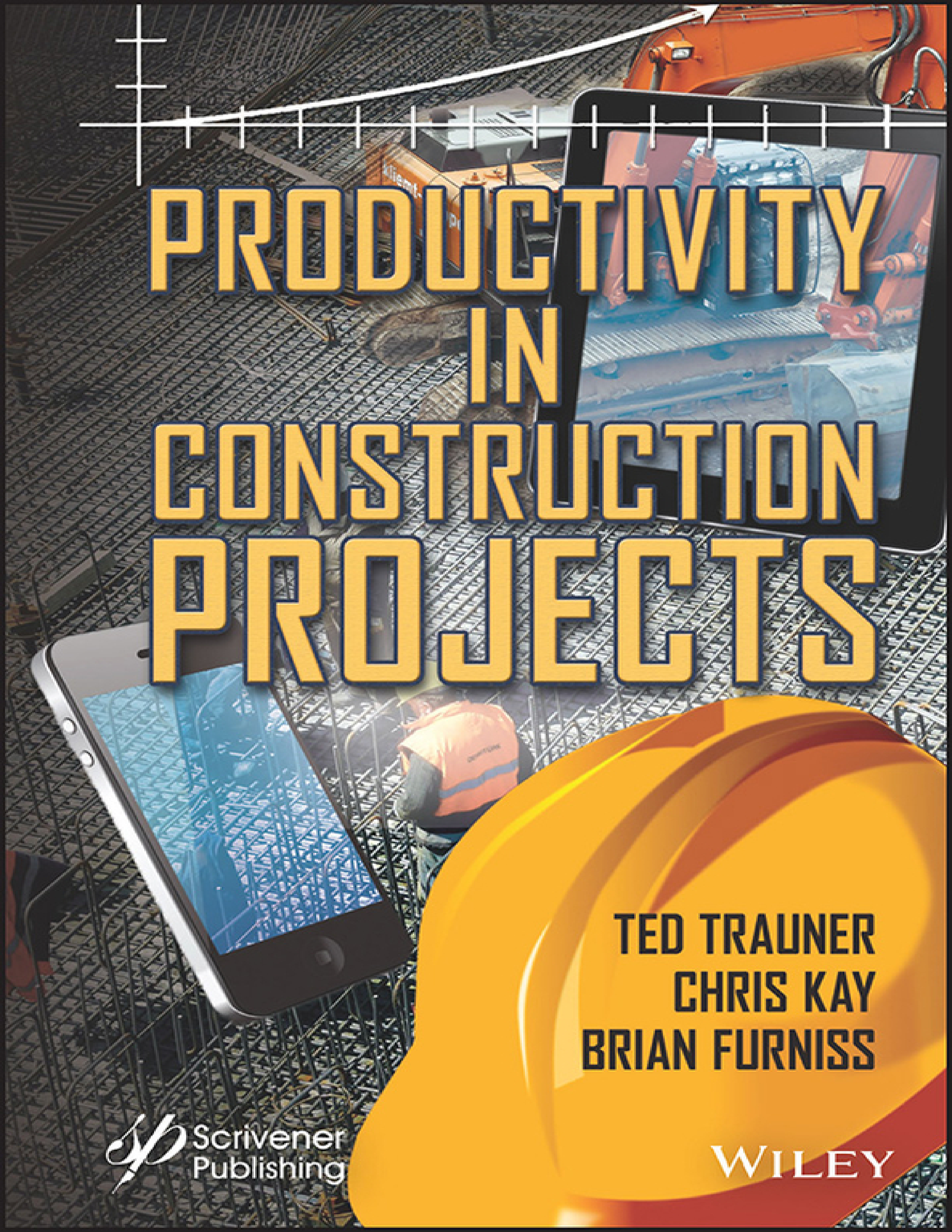
PRODUCTIVITY
IN
CONSTRUCTION
PROJECTS
TED TRAUNER
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Scrivener
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Productivity in Construction Projects

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1
Purpose

Why should anyone read a book on productivity, particularly one about productivity in construction? For many people and entities in the construction business, productivity probably hasn't been of primary importance in the scheduling and execution of the work. But in today's construction environment, productivity should be a primary focus for everyone's future success.

Without a doubt, the construction industry is challenged today more than ever before. Many new construction opportunities exist, yet the industry has a dearth of subcontractors to rely upon to accomplish much of the work, and this was before skilled labor shortages and a pandemic hit the industry. Projects have even tighter budgets and shorter time frames imposed upon them. What this means is that projects cannot afford delays, mistakes, or missteps. Every party involved needs to perform its work as efficiently and expeditiously as possible. Estimates must be accurate, augmented management staff must be applied to projects, and management must be ever vigilant to identify and resolve problems as soon as practicable. In today's construction environment, with its heightened demands, a continuous and concerted focus on productivity is crucial.

Whether the reader is a construction professional, a contractor retained to construct a building or renovate an existing one, or an owner with a business plan for its new building, the concept of productivity in construction is intertwined in so many aspects of the work. Here are just a few examples:

- A contractors’ bid is based on certain assumptions/predictions/estimates concerning construction productivity.
- The assignment of time or durations to specific construction activities is based on assumptions/predictions/estimates concerning construction productivity.
- The type of equipment utilized for specific construction tasks is based on the productivity that must be achieved.
- The size and makeup of construction crews is driven by the productivity desired for a specific activity in a specific environment.
- The cost of the work flows directly from the productivity of the crews and equipment on the project.
- The overall project schedule is dependent on the productivity for each of the activities in the schedule.
- The overall profitability of the project is a direct function of the productivity that can be achieved on the project.
- The overall long-term viability and functionality of the project is a direct function of whether the contractor took “short cuts” in the construction process when it was discovered that the project’s productivity, and thus the contractor’s profits, were being adversely affected.

These examples demonstrate the pervasive nature of productivity within the construction project, as well as its daily importance. Unfortunately, the authors have seen too many parties in the construction project begin to truly focus on productivity only very late in the process—typically when they realize productivity has not been achieved, or not to the levels originally anticipated.

Owners, contractors, sub-contractors, and construction professionals seem to express concern only when they finally realize there is a cost overrun in a specific area of work, or when activities are taking longer to perform than the time assigned. They become rightfully alarmed when forced to use longer work weeks and overtime on a daily basis. But by then, it is often too late.

In our collective experiences, we have encountered construction personnel who accept the general proposition that construction productivity is important on a prospective or forward-looking basis, but very few actually put that proposition into practice. Instead, their attention to productivity typically occurs when they look at it on a retrospective basis. By then, it may be too late to undo what has occurred. However, we can analyze what has occurred to determine the cause of the problem and, hopefully, seek a solution.

Perhaps the single most important lesson the reader should learn from this book is that any improvement in productivity, and the ability to adequately measure any shortcomings of actual productivity on the project, must begin with a comprehensive and detailed analysis of productivity on a prospective basis. We have seen time and again that owners, contractors, litigators, and consultants will expend hours and hours retrospectively attempting to quantify the amount of productivity that allegedly has been "lost" as a result of changes to the project during construction. If even half (or less) of those same hours were spent prospectively, the problem may never have occurred, and the additional legal costs (and time associated with a legal dispute) would have been avoided. Even if the problem persisted, the work to quantify any such losses is already more than half completed. We encourage the reader to adopt the more proactive approaches described in this book to avoid these kind of problems—and subsequent legal disputes—that have plagued so many construction projects in the past.

Performing the work of identifying and monitoring productivity analytics on the front end will increase the reader’s chances of achieving a desirable result on the back end. Interestingly, what we describe as necessary work at the start of the project can actually reduce the amount of work that is necessary to be performed later in the project, or in subsequent litigation. Once an organization uses these processes at the beginning of the project, its employees will soon discover that the implementation and mastery of the productivity methods gets easier over time. Each project further increases an organization’s body of knowledge and experience. If that organization then employs those lessons learned from preceding projects to its future projects, the organization will complete more projects on time and on budget, and earn greater profits—and future business. That is the essence of successfully harnessing productivity.

We recognize that some problems will nevertheless arise on the job site that result in the parties suing each other, either in court or in arbitration. Having spent considerable time on both, we also write this book to help the reader better understand how the dispute resolution process works, as well as the benefits and weaknesses of pursuing litigation and arbitration.

Thus, the second most important lesson to be learned from this book is that when parties find themselves in litigation or arbitration, they need to retain knowledgeable and experienced expert witnesses that employ credible and reliable methods of quantifying productivity losses. We have long believed that litigants in construction disputes made major mistakes when they did not attempt to use the “measured mile” approach to determine if there was a loss of labor productivity on a job site. The measured mile approach is predicated on the use and comparison of the actual facts contained within the data generated at the job site.

We do not want to see the next generation of owners, contractors and sub-contractors fall into the same trap as their predecessors, whose experts were apparently unable or unwilling to utilize a measured mile approach. As the reader will see, over the last 20 years the courts have essentially agreed with our point of view. We will show the reader the measured mile approach, provide actual case studies demonstrating its use, and how regression analysis may fit into that analysis process.

Along the same lines, we have long believed that litigants in construction disputes made egregious mistakes when they retained experts who relied heavily upon “industry standards,” a collection of general studies authored by various groups over the last several decades. Here again, we do not want the next generation of owners, contractors, and subcontractors to make the same mistakes. As the reader will see, over the last 20 years the courts have agreed with our point of view in almost all instances. Many cases have been lost because the party’s expert relied solely or significantly on such industry studies, without truly understanding the basis of those studies, and whether they were applicable to the subject project.

The third overarching message we emphasize in this book is the benefit of changing the workplace culture. Over the course of our respective careers, the authors have encouraged parties to collaborate to solve problems when they arise, rather than casting blame towards the other parties and engaging in defensive measures that result in lengthy and costly litigation or arbitration. The fact that the authors are owners, attorneys, and engineers collaborating on this book underscores our belief in the need for the kind of give-and-take, by everyone involved, to effectively and efficiently solve the problems that frequently arise on a construction jobsite.

Using that collaborative approach, we believe it is time for a different on-the-job culture, one that is significantly assisted by the implementation of new software and technology. With the adoption of a new culture and new software, parties can collectively create a schedule predicated on the same kind of units used in creating the measured mile approach. Such a construction project schedule would cause the parties to look at work per man units, and thus enhanced labor efficiency, at the outset of construction. Such a schedule would also lend itself to having the parties periodically review on-the-job productivity in real time and make real-time adjustments.

The basis of our recommendations come from decades of experience engaged in all facets of the construction process. Ted Trauner is a nationally recognized expert in the areas of scheduling, construction management, cost overruns and damages, construction means and methods, and delay and inefficiency analysis.

Ted has either managed construction or evaluated problems on virtually every type of project including transportation, water and wastewater treatment, process and manufacturing, power, medical, educational, commercial, correctional, hotels, condominiums, residential housing, and athletic facilities. For over 45 years, Ted has participated in the analysis and resolution of construction claims, managed many types of construction projects, and provided scheduling and training to the industry.

He has testified as an expert witness on delays, inefficiency, disruption, differing site conditions, excessive changes, extra work, termination, productivity, structural analysis, construction means and methods, and cost overruns and damages.

Ted lectures, conducts seminars, and has developed and presented training programs on multiple topics including construction claims, specification writing, partnering, and construction management to thousands of construction professionals throughout the world.

Ted is the author of the following highly-regarded construction texts; *Construction Delays, Third Edition; Managing the Construction Project; Construction Estimates from Take-Off to Bid; Construction on Contaminated Sites; Construction Delays (1st and 2nd Editions);* and *Bidding and Managing Government Construction*.

Prior to his work in the private sector, Ted was an officer in the U.S. Army Corps of Engineers for 11 years. He was Military Assistant to Construction Operations of the Philadelphia District, where he was Resident Engineer for major highway bridge rehabilitation, was involved with the construction of major gravity earth dams, and also advised on regulatory affairs for the District waterways.

Chris Kay was a trial lawyer for over 23 years and handled a wide range of construction disputes. As a construction litigator, he has extensive experience identifying the data and expert testimony needed to succeed in cases of all sizes and complexity. He also appreciates that a “win” needs to take into account the amount of time the client devotes to the litigation rather than to its normal business, and the cost of legal and expert fees. Thereafter, Chris became the first General Counsel in the history of Toys ‘R’ Us, and later its Chief Operating Officer. He was responsible for the construction of hundreds of new stores and renovation projects for existing stores, for the entire portfolio for Toys ‘R’ Us, Babies ‘R’ Us and Kids ‘R’ Us properties across the country. Chris later served as Chief Executive Officer for the New York Racing Association and spearheaded a number of capital improvement projects at that organization's three racetracks. As the owner of retail stores, malls, and sporting and entertainment venues, Chris knows that the corporate owner seeks to have the project completed on time and on budget, but not at the cost of the contractor taking detrimental "shortcuts" that may adversely affect the short-term operation or long-term viability of the completed facilities.

Brian Furniss has served in the construction industry for over 20 years, analyzing complex construction projects and providing expert testimony on scheduling, delays, productivity losses, and damages. As someone who has worked various construction sectors in projects ranging up to $15.5B, Brian has seen both exceptional management strategies and a fair share of missed opportunities. He is a licensed Professional Engineer (Industrial) in Florida, Texas, California, North Carolina, and Colorado, and a Planning and Scheduling Professional (PSP), Certified Cost Professional (CCP), and Certified Forensic Claims Consultant (CFCC) with AACE International. Brian is co-author of the book *Construction Delays: Understanding Them Clearly, Analyzing Them Correctly*, and has authored a number of articles for construction industry publications. He shares the experiences in this book knowing that every project provides a learning opportunity, and to help construction professionals increase the probability of project and company financial success.

We know of no other book where owner, attorney, and expert have collaborated together to explain and assess construction productivity, or inefficiencies at the job site. We have written this book primarily for the owner, contractor, and subcontractor—in that we write in practical yet specific terms. We also write extensively about what is required under the applicable law in construction disputes, so that the parties, their attorneys, and their expert witnesses can understand and appreciate those applicable legal standards as they begin to evaluate all the facts of their dispute—before they spend a ton of time and money in court or in arbitration.

Based upon our collective experiences, we offer the reader very practical insights and advice in straight-forward prose—starting with a chapter devoted to explaining what productivity is, how to measure it, and why it is important. We then devote a chapter to a simple but accurate explanation of a complex topic: what is a regression analysis and why it is important. We describe a regression analysis in terms we hope the reader will quickly understand, rather than relying on overly detailed explanations.

Precisely because there are too many post-construction disputes, we provide an explanation of how those disputes are resolved, and the best way for the reader to reduce or eliminate significant costs in that process. We also share with the reader the applicable law in construction cases, but not by providing lengthy string citations of several different court cases that force the reader to find and read the cases. Instead, we provide relevant facts of the cases we selected—cases we specifically selected for their informative or illustrative nature.

Finally, we provide guidance on how to achieve your goals of “winning” your case—in settlement or in court. Employing our recommendations will likely lead to fewer lawsuits and arbitration claims after the job has been completed. Even if there are some unresolved problems that cannot be reconciled at the end of the construction process, we believe this approach will narrow the issues in dispute and make for a less costly resolution process. None of the authors, including the attorney, want needless or needlessly expensive litigation. We hope this book will help some readers avoid such unpleasant and costly situations.

2
Productivity in Construction

During much of the past two centuries, productivity was a driving force in this country and throughout the world. The ability to produce and distribute goods in an efficient and cost-effective manner drove the financial success of nations. The United States became a world power not solely because of military might. Its rise was also driven by the successes it had in industry. American industry moved from hand tools to assembly lines to robotics in search of higher productivity. The U.S. applied this same production focus to agriculture, not only feeding this country, but also being able to export food to the rest of the world. The ability to produce efficiently, to achieve high levels of productivity, has been key to America's economic success.

Workers have experienced tremendous changes during the past century. The basic manner in which they earn their livelihoods has been dramatically altered from farming and hunting in the 17^{th} century, through the factories of the industrial revolution in the 18^{th} and 19^{th} centuries, to the Internet workplace of the 20^{th} century and today. Many of us remember our parents putting in their nine to five in a routine that varied little. But today, our work environment is drastically different. We rely on computers and robotics to handle many of the chores we formerly labored through. The United States, in particular, has moved from an industrial base to a service-oriented economy, but the same focus on productivity applies— and has been the key to many companies' success.

The Continuing Importance of Productivity in Construction

Despite operating in the Internet Age, we still rely on manual labor to construct our homes, high-rises, power plants, airports, and highways. In fact, construction is one of the few career paths that has not changed substantially in the last century. Though the industry benefits from more sophisticated equipment, more advanced designs, and a greater choice of materials, it still relies on construction workers to put the pieces together to create a functioning system to meet our needs. But the same focus on productivity that now applies to both manufacturing and service-oriented businesses can—and should—apply to construction project planning and execution as well.

Construction, like any other business, is driven by the bottom line. Construction managers, general contractors, subcontractors, and specialty contractors are in the construction business to make a profit. One of the most significant factors affecting that profit is the productivity or efficiency of the construction tradesmen working on the project and the construction equipment utilized on the project. Consequently, construction productivity is extremely important to contractors.

Productivity is also important to owners of construction projects. If workers on a project perform in an inefficient manner, the work may be completed later than required by the contract, much to the disappointment and lost revenues of the owner. In such situations, owners may also face claims for additional payments advanced by the contractor for lost productivity. Owners also need to be concerned about situations where the contractor takes short cuts to expedite the project. These shortcuts, in many cases, diminish the useful life of the building or compromise some aspect of the facility’s operation—all of which adversely affect the owner’s investment in the property. Architects who design facilities that cannot be constructed efficiently may drive the cost of the project so high that it will be cancelled for budgetary reasons. Hence, all parties involved in a construction project have an interest in maximizing productivity on the job.

What is Productivity?

In its simplest form, productivity or efficiency is the relationship between a given outcome and the resources expended to produce that outcome. In simpler terms, it is units of work over units of input (or the inverse). For example, presuming a contractor is diligently tracking work on a project, a daily record of work performed may show that 400 feet of 4″ pipe was installed with 40 man-hours of effort. Simplifying that means that the work crew was achieving a measured productivity of 10 feet of pipe per man-hour (400 feet divided by 40 man-hours). The inverse of that would be 40 man-hours divided by 400 feet of pipe or one tenth of a man-hour per foot of pipe (40 man-hours divided by 400 feet of pipe). We can readily relate to productivity in manufacturing when we think of how we might make a certain number of widgets during a certain period. Because the manufacturing facility requires a certain amount of resources for each minute that it operates, we would want to produce as many widgets as possible for every minute we are running our production line. Due to the fact that assembly line tasks are generally repetitive, with few (if any) variables, the efficiency of the manufacturing operation can be measured and evaluated easily.

By now, it should be apparent that productivity is a ratioed comparison of quantity of work achieved to hours expended to complete that quantity. We have seen the terms "productivity" and "production" used interchangeably. While the output measure is typically the same between the two terms (quantity of work complete), the input of the two terms is very different. As a result, the production is not the same as productivity. Let's expand on this for a minute.

Production is primarily focused on output. It is often expressed as the production of an overall steel fabrication plant by month, a country's output for the year, or the amount of rebar placed in a day. Production is output compared to a duration-based input. The production rate is the output expressed against that unit of time. The output of a cell phone manufacturing plant may be 300 phones per shift.

What production does not explain is the resources input to achieve that outcome. This is where productivity comes into play. Productivity changes the input from a duration-based unit to a resource-based unit. While the production rate may remain constant when comparing two time periods, the productivity rate may vary greatly. To illustrate this point, let's presume that in two different time periods, the production rate of that cell phone plant remained consistent at 300 phones per shift. However, the productivity during the two shifts was different. In the earlier time period, a single production line was used that had 5 workers and each worker worked 8 hours per shift (let's ignore the use of robotics in phone production for the sake of simplicity). The earlier time period had a productivity of 300 phones per 40 labor hours, or 7.5 phones per labor hour (300 phones divided by 40 hours). In the later period, two production lines were used as the plant was anticipating shutdowns for preventive maintenance and the plant wanted to maintain its shift production rate. Each production line had the same hours per shift. So in the later period, 300 phones were produced using 80 labor hours (two shifts at 40 hours per shift), resulting in a productivity of 3.75 phones per labor hour (300 phones divided by 80 hours). Despite production being the same between the two shifts, the productivity in the earlier shift was twice as good, or 100% better, than the productivity during the later shift. Conversely, one may argue that the preventive maintenance caused a productivity loss, or inefficiency, of 50% in the later period. This example demonstrates the differences between production and productivity rates, and that even when there are equal production rates there may be very different productivity rates.

Productivity in construction is a bit more difficult to define because, unlike manufacturing, construction tasks that may appear repetitive, actually may vary to some degree. For example, a worker on an assembly line normally is repeating the identical same task with each widget that passes his/her station. A construction worker, on the other hand, may be repeating similar work, but a variety of factors will make each task a bit different and, therefore, not executable in precisely the same manner every time. These variations can be significant. For example, an electrician may spend an entire day installing 1″ conduit. It may seem that because the conduit is all the same size, the productivity should be uniform throughout the entire day. However, the conduit runs are likely to be located in different areas and at different heights. Some conduit runs may be waist high in an open area. Other conduit runs may be ten feet in the air, requiring the use of a ladder or scaffold to perform the work. Still other conduit runs may be vertical, while others are horizontal. And each conduit run may be anchored or supported in a different fashion. There may be hundreds of variables that enter into the manner in which the conduit is installed: ten-foot sections or smaller sections; numerous elbows; working around ductwork or plumbing lines; no drywall installed, or drywall installed on one side; the presence of other workers in the area; hot or cold working conditions; damp or dry working environment; well-lit or dark workspace. The list of real-life variables at construction sites goes on and on. Each of these factors can affect the speed or efficiency that the electrician can achieve in installing the conduit.

In the interest of further illustrating some of the variables that distinguish construction productivity from productivity in the factory setting, another example is worthwhile. Suppose a construction contractor is excavating soil from an area. The quantity of soil that can be excavated during any unit of time is dependent on many different elements. The soil may vary in hardness or degree of compaction. Some areas within the excavation may be wet, while others are dry. The operation may be in an open area for some portion of the work and far more restricted in other areas of the excavation. As a consequence, the speed at which the material can be excavated may vary over the course of the day.

The problem in analyzing construction productivity is that, in contrast to the manufacturing facility, the work cannot be isolated and maintained in a controlled environment. This does not mean that construction productivity cannot be managed or controlled. In fact, many of the most significant factors that affect construction productivity are within the control of the project management team. It is precisely these factors—factors that can and should be controlled by the project management team—that are addressed in this book.

We recognize there are some areas over which we have no control, like weather. But even in those areas, we can properly estimate the weather's potential effect on the workers' productivity during inclement weather, and then plan accordingly. The key to maximizing productivity, in both those areas over which we have control and those where we do not, is to properly plan ahead of the project's commencement of construction and continually evaluate that plan throughout the project. Let's take a moment and identify factors that are controllable and non-controllable.

Controllable Factors that Affect Productivity

There are many factors that we can control that will affect the productivity achieved on the project. While these are discussed in more detail in the remainder of the text, it is worthwhile to briefly identify them here.

Construction Schedule: The schedule we create for the project dictates the sequence of work and the time allotted to complete specific activities. Obviously, both the sequence and the duration allowed can affect the productivity achieved. If we structure the work such that our sequence of operations is not optimally efficient, we will see a corresponding reduction in the productivity that can be attained. For example, if the project manager plans to drive underwater piles for a pier and excavate or dredge the material from between the piles after they are driven, this may be less efficient than first dredging the material and then driving the piles. While there may be good reasons for choosing this sequence, the project manager must accept the reduced level of productivity. Consequently, our planning and sequencing of the work directly affects the productivity we will achieve.

Equipment: The type and amount of resources we assign to specific tasks will affect the productivity of the task. If the project manager utilizes equipment that has limited production when it is possible to use more efficient or more productive equipment, the direct consequences must be recognized and accepted. For example, if a contractor chooses to perform excavation with a small backhoe when a larger piece of equipment would yield better rates of production, that should be factored into the plan. Problems arise when an estimate is based on optimal production with equipment that is never utilized. Similarly, if the crews assigned are either too large or too small, the efficiency of the operation can be adversely affected. Resources are an important element of the productivity equation.

Application of Resources: The duration allowed for a task and the number of shifts to which resources are applied will also bear on the efficiency of the work. We address the use of overtime, extended workweeks, and multiple shifts in more detail later in the text. Suffice it to say that there has been general acceptance that excessive overtime, extended workweeks, and multiple shift work may reduce the productivity of the workers. In most cases, we can control the use of these approaches.

Site Layout and Management: The manner in which we organize the site also can affect our efficiency. This is different than our organization or sequencing of the work itself. In the construction industry, it has been demonstrated that how the site is organized, such as where we store materials, where we marshal deliveries, how we distribute materials, and how we make tools and supplies available, can impact the efficiency with which the work is performed. For example, on a large process plant project, a contractor might set up its parts trailer on a remote corner of the site in order to allow easy access for deliveries. Unfortunately, that contractor may later discover that as the workers require parts for construction, the remote location may require them to walk a long distance to acquire these parts. This might result in a reduced