

DRIVING DOWN CONSTRUCTION PROJECT LABOR COST

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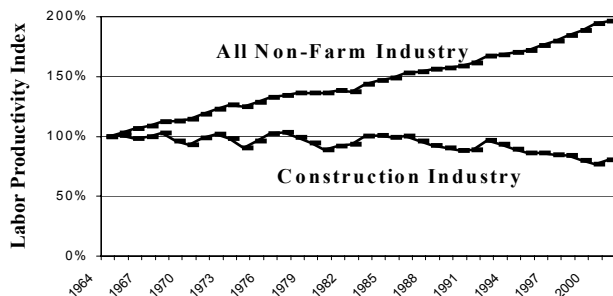
ABSTRACT: Systemic inefficiencies in industrial construction projects can no longer be overlooked in a competitive industry operating at low profit margins. Major opportunity to improve construction productivity is available by gaining quantitative insight in the performance of the construction 'production' process. Measurement of the efficiency of the construction work process during project execution provides metrics that differentiate non-value-added and wasted labor hours from productive activity. Continuous statistical monitoring of workforce activity is a useful, complementary management tool to continuously improve construction productivity and drive down costs without affecting quality or safety. Cases that demonstrate the importance of activity-based value analysis of the work process, and resulting significant cost savings are presented.

1. CONSTRUCTION PRODUCTIVITY

1.1 Declining US construction productivity

Challenging economic conditions have construction owners and managers looking for ways to reduce cost. The cheapest solution, however, is not necessarily the most cost effective. But how to tell the difference? Many executives do not trust their project performance measures enough to make confident decisions. Commonly used measurement systems are antiquated – not management tools to improve performance and reduce cost.

In spite of cost control, planning and scheduling, design practices, quality control, pre-fabrication, information technology, craft training and safety – which over the years have been believed by the industry to offer opportunities for productivity (Arditi & Mochtar 2000) – US construction productivity is on the decline (Teicholz 2003).



Sources: U.S. Bur. of Labor Statistics, U.S. Dept. of Commerce, Paul M. Teicholz

Figure 1. US construction productivity trend vs. the economy, as measured in constant contract dollars per field labor hour. ('All Non-Farm Industry' includes Construction).

In fact, construction productivity has been lagging behind the U.S. economy for decades; see Figure 1. Construction labor costs per dollar of investment continue to increase. If construction would have achieved the productivity growth of the overall U.S. economy, labor requirements in 2001 would have been less than half what they were in 1964.

1.2 Importance of the construction work process

It's cliché that, if you don't know you have a problem, you won't solve it. During the execution of construction projects, systemic inefficiencies may go unnoticed – they are 'transparent' to the participants because of traditional organizational practices and long-standing field habits. Similarly, at the management level, entrenched inefficiencies may not be revealed with the usual performance indicators due to 'buffers', embedded in historically based schedule and budget estimates.

As presented in this paper – based on field experience of applying systematic statistical value analysis on hundreds of industrial construction projects over more than two decades – managing and controlling the efficiency of the construction work process can significantly raise construction productivity.

Koskela (1992) pointed to the production-view of construction, which helps explain the possibility of applying inferential statistics, drawing information from sampled observation of construction activity, to the construction process. Well-known in manufacturing and service industries, the process forms the basis of a management approach using statistical analysis to measure and improve process performance (Deming 1986).

Process-based performance improvement includes:

- Measure level and variation of the process
- Identify and eliminate causes of variation
- Raise the level of process performance
- Identify events that could disrupt the process

Factors that cause construction process variability must be identified and constantly minimized. At the same time, the process must be brought to a higher level of productive performance. Any key events that can significantly interfere with the process must be identified, and action taken pro-actively to minimize their impact.

From time to time, productivity of skilled construction workers has been studied by so-called 'wrench time' studies – often, regrettably, used in faultfinding rather than problem solving. Nevertheless, systematically applied statistical analysis of workforce utilization as a tool enables managers to steadily lower the amount of labor required on labor-intensive projects by as much as one-third, or more.

The premise is, that a competitive construction work process requires work activity that adds maximum possible value to resources – by converting them efficiently, effectively and safely into a completed project that satisfies the customer.

2. CONSTRUCTION PROCESS MANAGEMENT

2.1 A need for meaningful performance metrics

Among management's usual questions are: are we on schedule, are cost projections being met? Conventional construction management is focused on planning and controlling outcomes, not on the process. Project controls are typically set up to 'manage the contract', and ensure schedule and budget expectations are met. Feedback of results of planning and control is necessary for management to decide whether or not and which corrective action to take. But, alas, basic control data are accounting-based outcome measures that usually arrive too late for viable management action.

Project performance indicators conventionally used to determine performance are ratios of actual results to estimates, such as actual cost vs. budget or progress vs. schedule. But, if out-of-line, such estimate-dependent metrics provide little actionable information about the root causes of problems. A mix of performance drivers or 'leading' indicators, such as efficiency, and 'lagging', outcome indicators is needed for an improved management system (Kaplan & Norton 1996).

2.2 The 'black-box' model construction process

The conventional construction management model emphasizes planning – 'to do better, plan better' is often advocated. Consequently, the focus tends to stay too much on the planning process, and not enough on what happens once plans are put into action. No matter how 'good' the planning is, construction projects are dynamic and complex with frequent unanticipated events, interferences, and constraints.

Actually, the complexity of the execution process is sometimes so great that the production process is implicitly assumed indefinable and dealt with as a 'black box' – to not be overwhelmed by its many details, uncertainties, and inefficiencies. Similar to a large construction project, a black-box has these elements: variable inputs, such as the amount of labor, a unique output, i.e., the completed project, and many internal interactions and relationships (Schoderbek, Schoderbek & Kefalas 1990).

Valuable, new insight in what happens within the dynamic, complex 'black-box' process can be obtained by operational monitoring of the efficiency of the work process. The proportion of productive activity, or: productive labor utilization is a useful, activity-based 'leading' indicator of efficiency and a (partial) measure of productivity of the work process, as in:

$$\begin{aligned} \text{Efficiency} &= \text{Value Produced} / \text{Value Invested In Labor-Hours} \\ &= \text{Productively Used Labor-Hours} / \text{Total Labor-Hours} \\ &= \text{Productive Work Activity} / \text{All Activity} + \text{Non-activity} \end{aligned}$$

2.3 Variability of the construction process

It comes, perhaps, as no surprise that considerable variation in productive activity is not uncommon on a large job site. This variability and average level of productive utilization of the workforce can be measured to characterize the capability of the construction process supplied by a constructor. One of the tools of statistical analysis of the work process is a scatter diagram, which shows the relationship between the average percentage of productive labor utilization and the time of day.

Consider, for example, a Clean Air Act SCR (selective catalytic reduction) construction project at an existing fossil power plant with a workforce of an approximately 350. Productive labor utilization data collected on dayshifts over a period of months are represented in the scatter diagram of Figure 2.

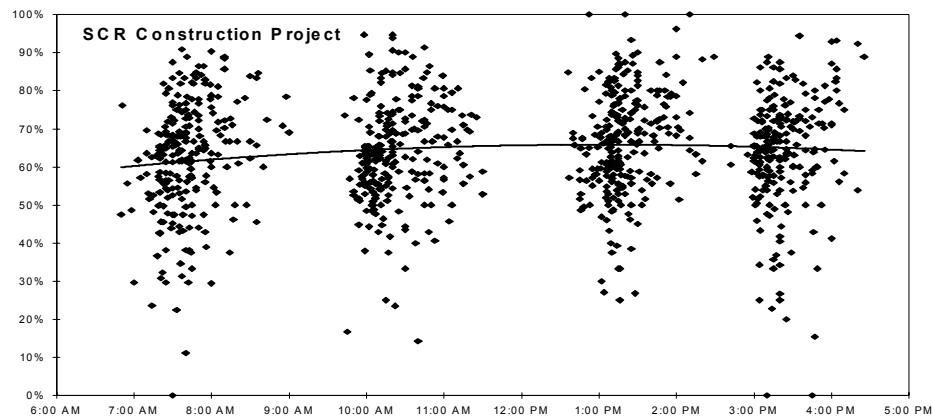


Figure 2. SCR construction process variability and average (trend) level of productive utilization of the overall workforce over the course of dayshifts. (Data points plotted are average workforce utilization measured vs. sampling tour start times. There were three breaks when no data were gathered).

Very high variability of labor utilization around the average or mean value was observed on this project, signifying poor ability to control the work process. The trend line, showing how the average productivity level of the process varies over the course of the shift, is created by regression analysis using basic statistical software. It suggests specific assignable causes, such as slow starts due to schedule changes or lack of information, lack of tools, excessive socializing, absenteeism, etc., and slow-downs towards end of shift due to workers leaving work early, e.g., to return tools to central tool storage, or foremen leaving the work areas to fill out timesheets elsewhere. The average productive labor utilization was measured at 64.2%. The standard deviation, a common measure of variability, is calculated at 14.34% for this process (assuming a normal distribution).

2.4 Uncertainty and unpredictability

The uncertainty arising from high variability leads to unpredictability of the dynamic construction process, and sometimes risks unpleasant surprises, such as schedule delays and budget overruns. Often, the workforce is assumed at cause, but it is more likely a badly planned or controlled work process arising from constant changes and interferences that cause below-par performance.

How can uncertainty be reduced? The answer is: through better information. Providing information about process performance reduces uncertainty and variability – one of the techniques of control that makes the system more predictable. The level of productive utilization in the work process must be raised and variability reduced by means of cause-and-effect analysis and corrective action on below-average results, (Deming1986).

2.5 A dynamic process model

Eliminating obstacles that cause inefficiencies in the work process maximizes productive utilization, which minimizes the amount of labor hours required to complete tasks. Fast, dynamic feedback enables management and supervision to flexibly and pro-actively manage and control the efficiency of the work process. The feedback control system in Figure 3 illustrates the idea:

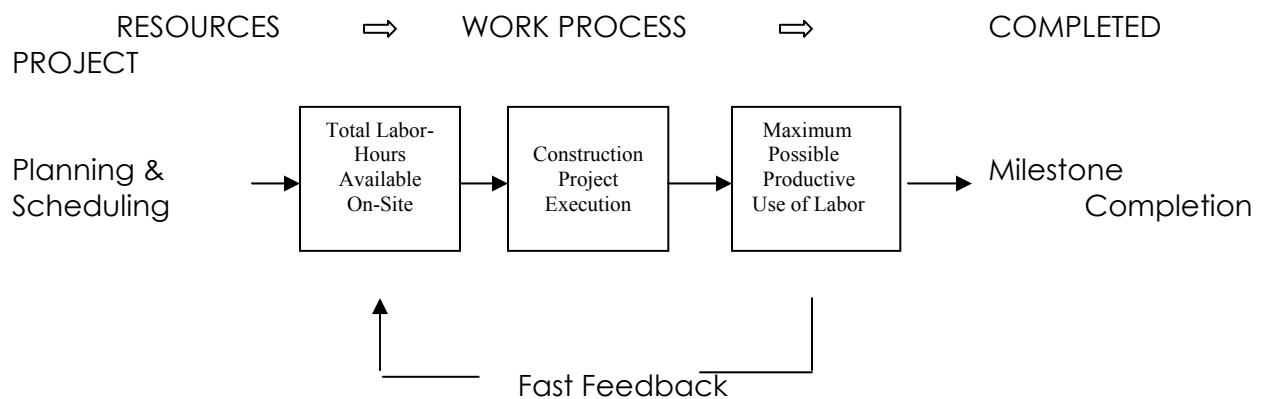


Figure 3. Dynamic feedback system for effective control of project execution by managing the efficiency of the utilization of the workforce.

2.6 Applying the process focus

Implementing this dynamic feedback system requires objective, statistical monitoring of field work activities. Throughout the workday, labor utilization is measured directly by activity sampling of the entire site and workforce. Expressed as percentages, the proportions of value-added productive activity, non-value-added activity, and lost or wasted time by the workforce are quantified. The percentage of productive utilization is an estimate-independent, real-time measure of productivity for which targets can be set.

The process focus complements the conventional project management approach. Starting in the project-planning phase with thorough analysis of the project scope, the process is planned and designed for efficient execution. To eliminate or minimize productivity constraints in advance as much as possible, optimal workflow and most beneficial site preparation are planned for the various stages of the execution phase.

2.6 Improving process capability

Continual random sampling measurement of workforce activity levels requires a disciplined, standardized procedure (such as described in DCAA Contract Audit Manual 2002). First, baseline labor utilization is measured; next, based on analysis of baseline results, project management sets challenging benchmark targets. Subsequently, daily measurement data are analyzed to determine systemic productivity roadblocks and their root causes. Management then decides on actions to further reduce variability and raise efficiency – there is always opportunity for further improvement in a process.

Communicating benchmark targets and feedback of measurement results, raises awareness of the requirements for efficient use of labor-hours at all organizational levels. For example, by widely distributing easy-to-understand daily pie chart reports, similar to the example in Figure 4. With management support, big changes can be introduced using little extra effort.

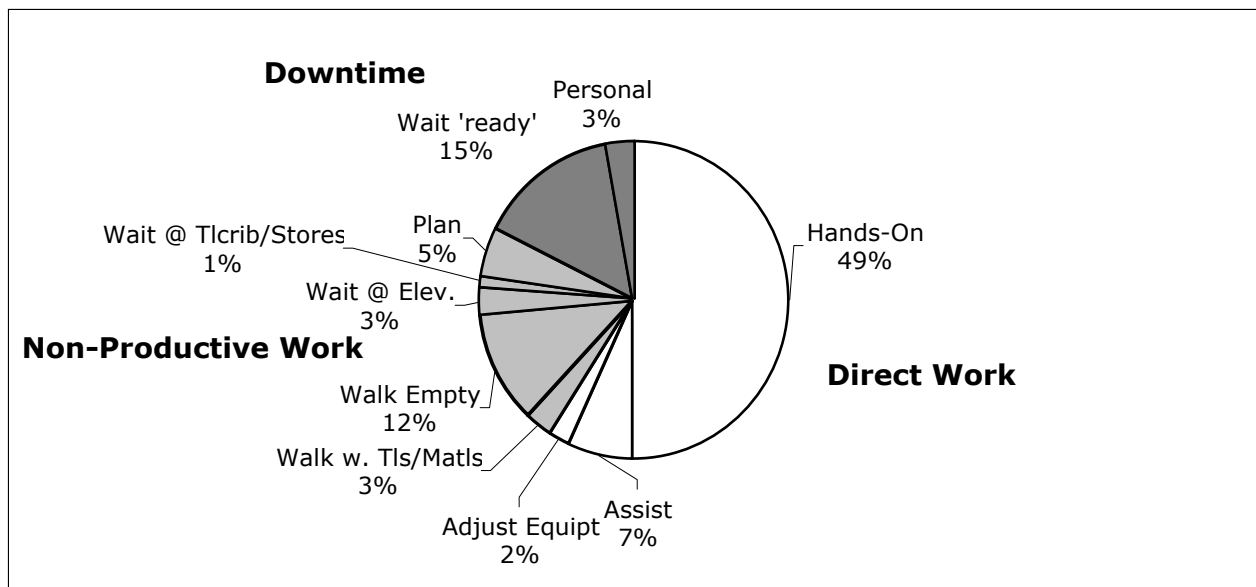


Figure 4. Sample format for daily site feedback of labor utilization measurement.

By allocating labor resources based on real-time, measured labor utilization, such as balancing the size of the workforce with actually available, do-able workload, the workforce will be staffed 'lean'. Crafts are hired 'just-in-time' (JIT) instead of 'just-in-case'. With typical project management software manpower is scheduled based on

planned, i.e., estimated task completions, but managers tend to keep extra manpower on hand, 'in inventory', because of unanticipated interferences, inevitable delays, and changes.

Under-utilized and wasted labor hours and the variability of the construction work process can be greatly reduced, and the average level of productivity brought up by taking prompt corrective action, e.g., by minimizing non-value-added, indirect work activity, such as excessive 'walking', or lost production time, such as 'waiting'- activities for which the customer does not want to pay.

The daily labor utilization data enable management to effectively control the process, meet or beat project cost targets and schedules, and mitigate the risk of overruns. As a measure of efficiency, it promotes flexible, pro-active supervision. Foremen learn to work 'smarter', ensuring crafts have all needed tools, supplies, information, facilities, and actually workable assignments at all times during work periods.

3. COMPETITIVE CAPABILITY

3.1 Successful construction process improvement

Experience on numerous industrial construction projects shows typical baseline productive utilization varies between 40% and 60%, with an average at about 50%. Work with the Tennessee Valley Authority (TVA) Fossil Group, a major US electric power producer facing competitive realities, is a representative case study (Seay 2000; Picard & Seay, 1996).

As it became evident at TVA that its 'partnering' approach of managing outsourced projects (involving some 3000 to 5000 unionized craft workers in a seven-state area) was not bringing construction costs down effectively, a strengthening of its performance-based contract with the two major constructors was sought. Implementation of third-party work process measurement and analysis was thus started in the spring of 1993 on in-plant maintenance outage and construction projects. A major feature in the contractual incentive is continuous process improvement – driven by continually 'raising the bar' of expected, measured productive labor utilization.

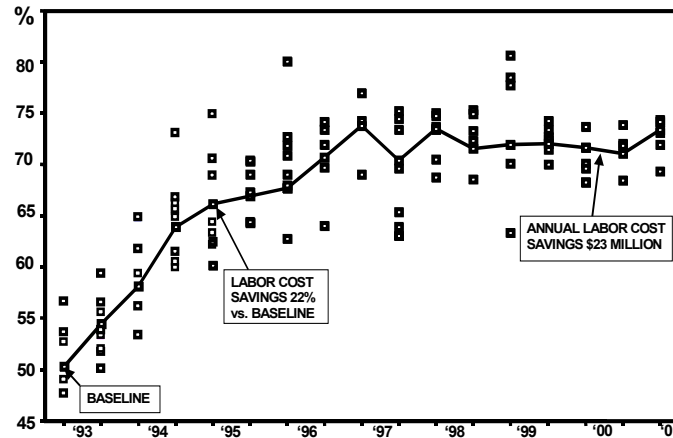


Figure 5. TVA Continuous improvement trend of productive contractor labor utilization percentage, from 1993 to 2001. Data points are averages plotted for measured in-plant construction projects, reported seasonally.

With proper preparation of and feedback to site personnel, the methodology can be readily institutionalized. It requires consistent adherence to statistical procedure and definitions by skilled work process analysts. Our decades of experience has proven that analysts' prior craft experience is a key attribute to acceptance and facilitates communication and cooperation on site. A side benefit of a well-organized, efficient work process – where barriers to productivity are constantly removed and craft needs are continually filled, thus making tasks 'easier' and more efficient to carry out – is better safety, quality of work and attitudes (Picard & Seay, 1996).

3.2 Competitive benchmarks

The trend chart of Figure 5 shows baseline productive labor utilization, measured at several projects, was 50% on average. Subsequent process measurement, analysis and continuous improvement caused ever-increasing labor cost savings. Two years into the program, labor cost savings of 22% compared to baseline costs were generated. Productive labor utilization moved from a baseline of 50% to the 72-73% level, i.e., a 45% productivity improvement.

Our practice at TVA and other major US companies (Picard & Boehm 1996) demonstrates that effectively managed projects can be expected to perform at a 70%-75% level of average productive utilization with variability of 6% - 9%, which can be considered a competitive level of capability for the industrial construction process.

In 2000, TVA Fossil Group reported saving \$23 million annually in labor costs through construction work process improvement (Seay 2000) - at a cost of measurement and analysis a fraction of the benefits gained by ensuring efficiency.

(Can the author share some experience on the type of personnel needed to perform such work, where does one get them and what is a range of "typical costs" to performance such in-depth labor surveys? Additionally, can the author address

whether performing such a labor survey would cause problems in a highly unionized area of the nation – i.e., violate union agreements or cause union problems?)

4. IN SUMMARY

Why should we care about measuring efficiency of the work process? Because reliable and accurate data to support construction project productivity measures are needed. Determining how to measure the efficiency of the construction process is key to the productivity measurement problem.

A fundamental construction productivity problem is that projects customarily apply project control, but little or no systematic attention is given to controlling the 'production' process. Project control focuses on project outcomes; process control complements project control by adding focus on efficiency and productivity of execution.

Production management can be seen as integral to the labor-intensive construction process. The process lends itself to helpful statistical analysis. Reduction of variability, and raising the level of performance are signs of an improving construction process.

While planning, estimating and project preparation are indispensable, measuring and analyzing the execution work process provides continuous daily feedback to continuously maximize the efficiency of the construction process.

New management insight can be obtained cost-effectively by objective statistical sampling of work activities in the field – and reduce labor-hour requirements by tracking costs back to work activities.

Continuous improvement then minimizes or eliminates non-value-adding activities and wasted labor hours from the work process.

Competitive performance benchmarks for the industrial construction process are suggested. The opportunity to significantly drive down construction time and cost by improving management of the construction process is real, cost-effective, and readily applicable.

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