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Lean construction

Make the execution of big capital projects more predictable and they become much cheaper

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The productivity revolution that has transformed manufacturing over the past 50 years has left the construction industry largely untouched. In fact, productivity in the sector is going backwards. While manufacturing productivity more than doubled over the 40 years between 1962 and 2002, construction productivity dropped by over 20 percent in the same period. Worse, capital projects, particularly large ones like dams, mines and highways, aren't just expensive and time-consuming to build, they usually take even longer and cost even more than expected. One study of 258 transportation infrastructure projects (rail, road and fixed-link) conducted by Aalborg University in 2002[1], found that nearly 85 percent of projects ran over budget, and in almost a third of those cases the cost overruns were 40 percent or more.

Much of the problem arises because today's big projects are getting more difficult. As miners exhaust easily accessible reserves, they must go after those in challenging geological conditions, for example; roads and dams are being built in increasingly remote and inaccessible locations. In these tough environments, the best-laid plans are likely to be upset by unforeseen difficulties, from harsh environments to problems obtaining materials or maintaining equipment. The difficulties on the ground are often compounded by skills shortages. Big projects are both complex and unusual, meaning many of the workers responsible for executing them will be learning on the job.

Tackling the root causes of variability

In response to these challenges, some companies are fundamentally rethinking the way they plan, manage and execute large capital projects, building on the same lean principles that have driven dramatic productivity and quality improvements in the manufacturing sector. This "lean construction" approach aims to dramatically reduce the variability so often seen in big construction projects, and then to minimize the cost of the predictable processes that remain. Lean construction is enabled by three key changes to traditional processes: a better model for the interaction between project owners and their contractors, the use of a strong performance management system to manage execution, and a new focus on developing the capabilities of frontline staff and their managers.

[1] Flyvbjerg, B. Skamris Holm, M. K., and Buhl, S. L. (2002), 'Underestimating Costs in Public Works Projects: Error or Lie?', Journal of the American Planning Association, 68(3), 279–95

A better owner-contractor interaction model

The use of EPC[2] contractors to deliver complete construction projects has led many owners to believe they have transferred construction risks to their contractors. Often, however, owners still end up paying for these risks. Even where contractors can see ways to mitigate delays and cost overruns, they may lack the decision-rights to implement them—where a solution calls for a change in a contractually agreed specification, for example. As a result, contractors may be forced to incorporate the impact of potential delays into their prices, either up front or through claims and change orders during project execution.

The best project owners refuse to accept the inevitability of delays and cost overruns by taking a much more active role in the project, supporting the contractor throughout the process and actively working with them to identify win-win cost reduction opportunities, rather than just administrating from afar. The owner's role includes ensuring that plans are both detailed and realistic, actively managing execution performance, helping to solve operational issues, reducing risks and aiding in the building of contractor capabilities.

A strong performance management system

All too often, the complexity of on-site activities during the execution of big construction projects makes it hard for those involved to get a clear a picture of progress, particularly middle-managers and staff on the ground. This can mean that important problems are discovered too late, compounding their effects.

A robust performance management system can transform the transparency of project progress. The best systems are built on a small set of straightforward metrics (measuring compliance with the construction schedule and with risk budgets, for example) but they are tracked rigorously, with a regular cascade of meetings to review the status of the project and a relentless focus on root cause analysis when issues are identified.

A focus on developing staff mindsets and capabilities

The skills of front line staff and their supervisors and managers play a critical role in the quality of project delivery. Projects need staff with the technical skills necessary to execute construction jobs, and they can't assume that enough people with the right capabilities will be available, particularly in remote or developing regions. Lean construction demands other skills too, from improved planning capabilities to experience in waste reduction and root-cause problem-solving techniques. Successful companies use a systematic approach to develop these skills, providing training for both their own staff and those of contractors, and making use of "field and forum" techniques that tightly link classroom training with on the job experience, supported by regular coaching and mentoring.

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[2] Engineering, Procurement and Construction

A different way of working

The lean construction approach doesn't just involve a different way of managing projects; it involves a different way of doing them too. In particular, companies following lean construction principles take a distinctive approach to the way construction is planned, the way tasks are executed and to their management of risk.

Planning

It has become standard practice at many companies to leave planning to the experts as much as possible. Specialized engineers working for individual subcontractors are given responsibility for developing detailed plans for their own packages of work, using experience gained on similar projects elsewhere.

Distributing the planning work in this way has some serious drawbacks, however. Synchronizing many separate plans can be difficult, as different subcontractors seek simultaneous access to the same site, or one subcontractor's work is delayed since it relies on uncompleted work by another. When problems arise during execution—if difficult conditions call for design changes, for example—or because work does not progress as quickly as expected, the resulting delays can rapidly escalate as different parts of the plan must be revised to cope with the disruption.

The Last Planner System, developed by Glenn Ballard and Greg Howell of the Lean Construction Institute[3], is increasingly being adopted to avoid this unsatisfactory situation. This approach uses collaborative, pull-based scheduling to build a series of integrated plans designed to deliver key project milestones. In sessions moderated by the project owner, teams including all the main contractors will work backwards from each milestone, specifying the work required to complete each section of the project, and the work that will have to have been completed before this section starts. They will then repeat the process for those previously required steps, and so on until the entire plan is complete.

During the execution of the project, the collaborative work continues. All contractors also participate weekly in look-ahead planning sessions which examine all the work scheduled for the next eight to twelve weeks to ensure that all the required preparation work is scheduled and the right materials and equipment have been procured and are scheduled for on-time delivery. Each week, contractors agree to detailed work plans for the coming week, based on the overall pull schedule and the previous week's progress, with clearly defined outcomes and resource requirements. Every day, shift start and end meetings are used to align working teams on required outcomes and review and record progress against the plan, using Percentage Plan Complete (PPC), a measure of the number of tasks that are actually completed on the day they were planned to be completed, as their primary KPI.

[3] http://www.leanconstruction.org/lastplanner.htm

Each week, the project owner conducts reviews of any areas of the project that have failed to complete at least 80 percent of the planned work in the previous week. In these reviews the owner and contractors will work together to find the root causes of the delays and generate solutions that will get the project back on track. Lessons learned are also fed back into the project plan by making improvements to preparation, communication or coordination to ensure that similar delays do not occur later in the project.

Adopting these steps can deliver rapid and significant improvements in schedule compliance. At one company PPC rose from 40 percent to 90 percent in a critically vital part of the project after only six weeks of regular reviews and root cause analyses with contractors.

Yard excellence

Yard excellence describes the application of lean manufacturing principles to construction activities in order to improve quality and speed by codifying, improving and standardizing key tasks. The power of yard excellence comes from the fact that even very large and complex projects contain a high degree of repetition at the task level. In our experience, it is common for 60 to 80 percent of the work on a construction project to be repetitive in nature.

The performance of repetitive tasks can usually be dramatically improved through a structured process of observation and improvement. The project owner can establish a baseline by studying a single task cycle as it is executed, identifying the time and resources required to complete the task, and separating that time into value-added elements (which contribute to the end goal of the task, like assembling steel or pouring concrete) and non-value added elements (which don't, like transporting materials or waiting for tools and equipment to become available). It is not uncommon for the value-added element of a task to be as low as 20 or 30 percent when it is first measured.

Armed with the initial assessment data, companies apply a range of improvement tools to eliminate waste and streamline value added tasks. One typical approach is optimized task preparation to ensure tools and materials are in the right place and the site is in an appropriate condition before work starts. Changes in methods can also be applied, for example by conducting pre-assembly offsite, or mechanizing tasks to speed them up. Careful design of tasks can also help to balance the workload between the available resources, so that staff don't spend so much time waiting for their colleagues. Finally, companies can take steps to improve the reliability and availability of critical equipment, using the same OEE (overall equipment effectiveness) improvement techniques used in manufacturing.

When the improved approach has been designed and tested in a subsequent task cycle, it is documented as an operating standard that is used to aid the planning and execution of subsequent cycles. The standard will define the resources, tools and time required to complete the cycle, together with all the necessary preparation work required. Companies can continue to improve task performance by measuring compliance with the standard in subsequent task cycles and, where deviations occur, conducting root cause analysis to find and fix the

issue, either by improving compliance on the ground, or updating the standard.

One company used the yard excellence approach to reduce tunnel construction time by 20 percent, cutting the critical path of its project by 30 days. Another used the same approach to double the quantity of steel erected every day during the construction of a chemicals plant.

Even non-repetitive tasks can often be made significantly quicker through thoughtful application of many of the same techniques, for example, by improvements to preparation work or improving the planning of resource deployment.

Risk management

All companies attempt to assess, measure and mitigate risk in large construction projects, but too many treat risk management as a one-off exercise. At the beginning of the project, they will typically draw up a risk register that includes the main sources of risk to the project, the probability of those risks occurring, their likely impact and any possible mitigation actions, together with their costs. Often, risk management stops there. Companies build the risk cost estimates into their budgets as contingencies and are not surprised when those contingencies are spent during the execution of the project.

Leading companies take a much more active approach to risk management. They run weekly risk management meetings with contractors on site, during which the risk register is reviewed an evaluated. Have planned mitigation actions been implemented? Does the progress of the project mean some risks are no longer relevant? Have new risks emerged or have unlikely events become more likely as a consequence of changes on site or off? To support their active risk management activities, some companies have created two key roles: a risk manager who is in charge of controlling the quality of the risk register and mitigation actions, and risk champions, with expertise in the management of certain risks.

Constantly updating the risk management plan in this way typically reduces the cost of risks. Companies do much more to mitigate risk events, especially those that arise during project execution, and the active approach also allows teams to find the best response to risk events when they occur, rather than simply dipping into the contingency fund.

The financial impact of such active risk management can be considerable. When the owner of one project discovered that it would need far more of a key building material than originally estimated, for example, it faced an additional $5 million in transport costs. As the issue was identified early, however, the risk management team was able to secure alternative, closer sources for the material, dramatically reducing the additional costs.

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Owners can capture significant value from the application of lean construction principles to large-scale capital projects in a variety of industries, including energy, mining, transportation and telecommunications infrastructure. That value comes from keeping projects on time and on budget, or from significantly reducing expected overruns. In our work, we have seen projects achieve 10 to 30 percent reductions in expected completion time and cost savings of 10 to 25 percent. Together, changes like these can deliver NPV improvements of 5 to 10 percent■

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