PART

III

Managing Costs and Profits

In this section we look at how to manage the costs and profits of a construction company. This must be done at the project level as well as at the company level. This section includes the following chapters:

- Chapter 7: Managing Costs
- Chapter 8: Determining Labor Burden
- Chapter 9: Managing General Overhead Costs
- Chapter 10: Setting Profit Margins for Bidding
- Chapter 11: Profit Center Analysis

CHAPTER

7

Managing Costs

In this chapter you will learn to monitor and control construction costs for materials, labor, subcontractors, equipment, other costs, and general overhead. You will also learn to measure the success of the project by monitoring profitability using the schedule performance index, the cost performance index, and project closeouts. These skills help financial managers determine the success of projects and identify problem areas on projects, regardless of whether you are a project manager or superintendent who wants to know how your project is doing or a general manager or owner who wants to know how well your project managers and superintendents are running their projects.

In this chapter we look at monitoring and controlling the individual costs as well as monitoring the costs of the individual project.

Monitoring and Controlling Construction Costs

For management to control costs, it must actively monitor costs, looking for potential problems and proactively address the problems. In this section we look at the five different types of costs—materials, labor, subcontracts, equipment, and other—as well as general overhead to see how management can monitor and control costs.

Material Purchases

Prior to making any material purchases, employees should obtain a purchase order for the purchase. The purchase order should include the quantity of materials ordered and the cost of the materials. Purchase orders should be approved by the project manager. The superintendent should be allowed to approve small purchases up to a specified limit—say $100 or $200—without approval of the project manager. The approval of the purchase order gives management a

chance to check and see if the material costs are in line with the budget and to ensure that only needed materials are ordered for the job. Small purchase orders for stopgap materials may be processed without costs but should include the quantity of the items needed. This is often necessary to keep the job moving. On every job some stopgap purchase orders are needed; however, a persistent pattern of stopgap purchase orders is a sign of inadequate planning, which is a major enemy to good cost controls. Material purchases may be handled as shown in Figure 7-1.

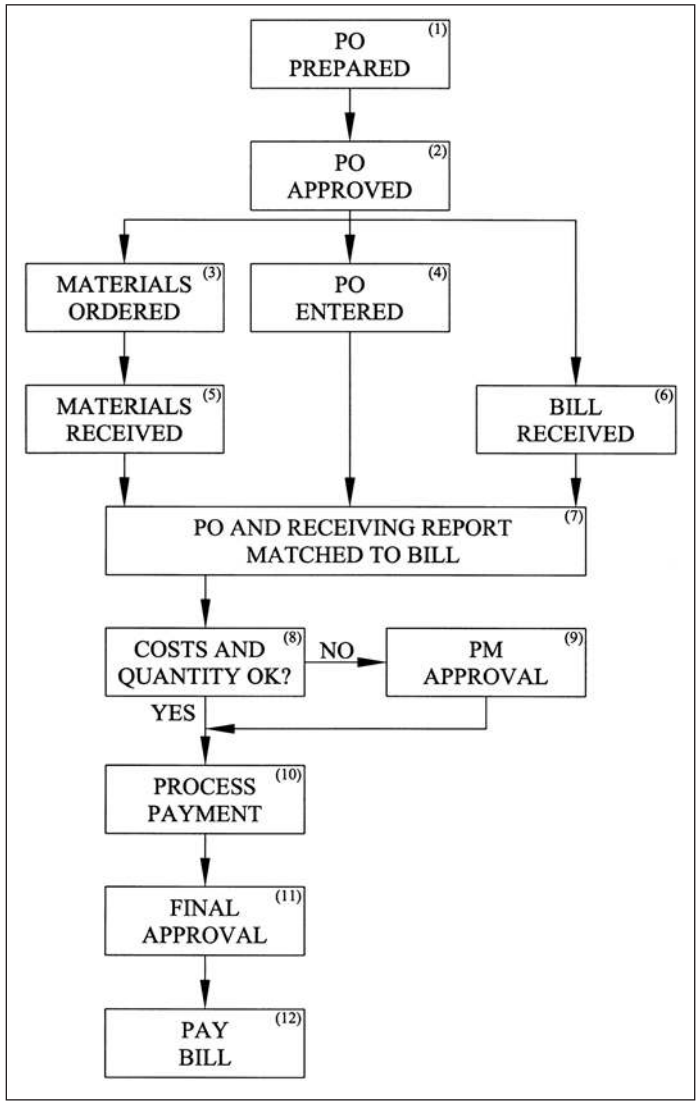


FIGURE 7-1 Material Purchases

A purchase order is prepared (step 1) for the materials needed and should include the quantity of materials, type of materials, the material costs, and the date the materials are needed. This may be done by field personnel, the estimator at the time of buyout, or the project manager.

The purchase order is checked against the budget and approved or denied by the project manager or, if allowed, by the superintendent (step 2). This gives the project manager and the superintendent the opportunity to seek other sources for the materials if the purchase order exceeds the budget amount before the materials have been ordered. For the project manager to check the purchase order against the budget, the total committed and noncommitted costs to date must be available. At the time the purchase order is approved the materials are coded to a job cost code. After the purchase order has been approved the materials may be ordered (step 3) by the party requesting the purchase and the purchase order is entered into the accounting system as a committed cost (step 4) by the accounting department.

When the materials are received, the site personnel should notify the accounting department that the materials have been received (step 5). This notice of receipt should include listing any missing or damaged materials. This notice is often done by sending a copy of the shipping invoice to the accounting department.

After the bill is received (step 6) it is entered into the accounting system and matched to the notice of receipt and the purchase order (step 7) by the accounting department. The quantities and prices on the bill are compared to the notice of receipt and the purchase order (step 8). If the material quantities or costs on the bill exceed the amounts on the purchase order or notice of receipt, or if the purchase order lacks costs, a copy of the bill, the notice of receipt, and the purchase order are sent to the project manager for reconciliation and approval (step 9). If the material quantities on the bill are less than the amounts on the purchase order and there are additional deliveries expected, the quantities received are noted on the purchase order so that they may be added to future deliveries. This is a common occurrence when ordering large quantities of material that cannot be delivered in a single shipment. The accounting system should allow for receipt and payment of partial shipments. If the material quantities on the bill are less than the amounts on the purchase order and no additional deliveries are expected, the purchase order is closed so that additional purchases cannot be credited against the purchase order. All bills that do not exceed the quantities or costs on the purchase order or notice of receipt do not need approval of the project manager (step 9) and are processed for payment (step 10). It is redundant to have the project manager approve all bills that do not exceed the quantities or costs approved by the project manager on the purchase order because the project manager has already approved these quantities and costs.

Prior to payment of the bill, the accounting department should send a list of suppliers to be paid to the project manager for final approval (step 11). This gives the project manager one last chance to withhold payment in the event there were problems with the materials supplied. Once final approval is received the accounting department may pay the bill (step 12).

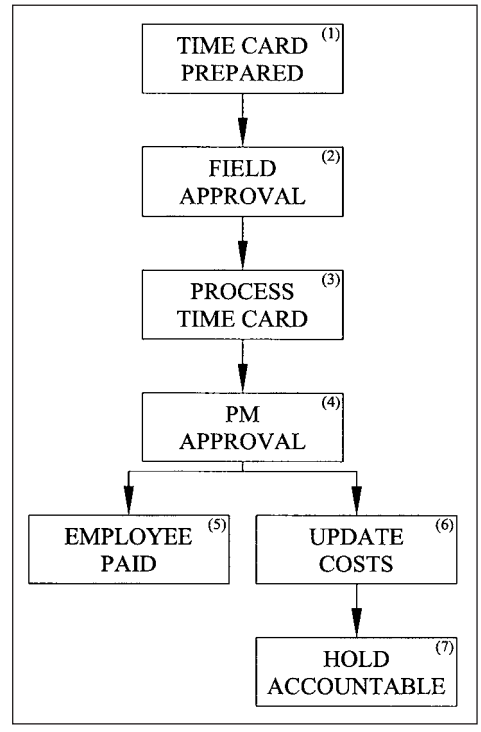
Labor

Labor is much more difficult to control than materials. With materials, the project manager has the opportunity to approve a purchase along with costs before the materials are purchased. With labor, the costs are not available to the project manager until the work has been performed and the employees' time has been entered into the accounting system, which may occur a week or more after the work has been performed.

A key to controlling labor cost is for the project manager to hold the superintendent and crew forepersons responsible for the productivity and costs of their crew. Labor may be handled as shown in Figure 7-2.

The employees keep track of their time on a time card (step 1). The time should be separated by the type of work being performed and should be consistent with the company's cost coding system and the budget for the project. The foreperson and superintendent check and approve the time card (step 2). The superintendent should make sure that the work has been coded to the correct job cost code. The superintendent will have better control of the labor costs if he or she reviews the labor hours daily. Once the time cards have been approved, the superintendent sends the time cards to the accounting department, where the time is entered into the accounting system (step 3). The number of hours worked, along with the costs, are then sent to the project manager for approval (step 4) and payroll checks are processed (step 5). With the new costs entered into the accounting system, the

FIGURE 7-2 Labor

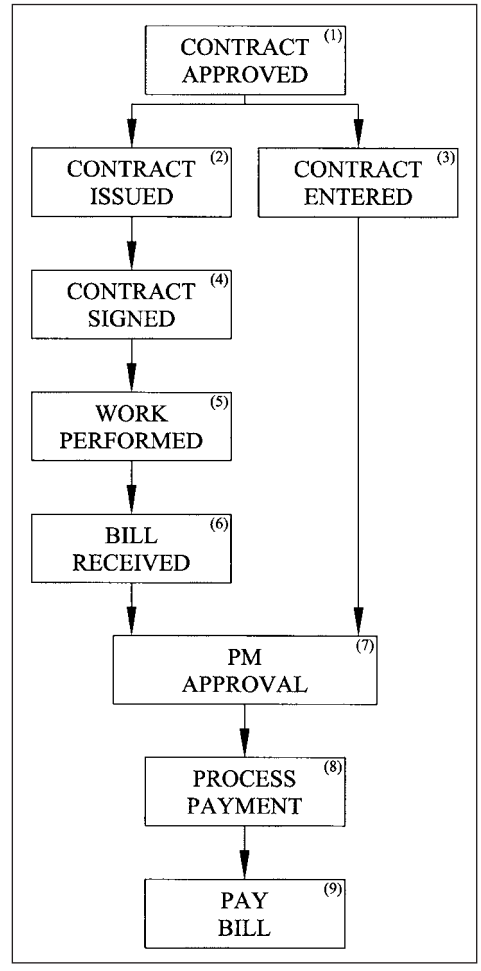


project manager may update the cost to complete and the total estimated cost at completion (step 6). Finally, the project manager should review the costs with the superintendent and the crew foreperson and hold them accountable for the weekly labor costs (step 7). If the project manager does not hold field personnel responsible for their costs, the company is simply reporting costs rather than controlling costs.

Subcontracts

Unlike purchase orders, all bills from subcontractors must be reviewed by the project manager prior to processing the payment. This is because most subcontracts require progress payments, which are based on the amount of work that is complete. Determining the amount of work completed is more difficult than determining the amount of materials that have been delivered to the project. For this reason the project manager must make the final decision as to whether the bill from the subcontractor is fair. Subcontracts may be processed as shown in Figure 7-3.

FIGURE 7-3 Subcontracts



The subcontractors' bids or proposals are checked against the scope of work and the budget. After selecting the best bid or proposal, a subcontract is prepared and approved by the project manager (step 1). This gives the project manager the opportunity to check the cost of the work against the budget, to seek other bids, make corrections to the scope of work, and negotiate the finer point of the contract before issuing the subcontract. Once this is completed, the contract is issued to the subcontractor (step 2) and is entered into the accounting system as a committed cost (step 3) by the accounting department. On receipt of a signed contract from the subcontractor (step 4) the project manager notifies the superintendent that the subcontractor can work on the project (step 5). The project manager should send the superintendent a copy of the contract so that the superintendent is aware of the contractor and subcontractor's responsibilities under the contract.

At the end of a billing period, the subcontractor submits a progress bill to the contractor (step 6). The project manager, often in consultation with the superintendent, reviews the bill and approves it for payment, resolving any differences in the amount of the work the subcontractor has billed for and the amount of the work performed on the job. The review of the bill may include a trip to the jobsite to inspect the progress or may rely on progress reports from the jobsite. When reviewing the bill, the project manager should check the bill against the contract amount. At the time the bill is approved, the bill is coded to a job cost code. After approval the payment is processed (step 8) and paid (step 9) by the accounting department. Change orders to the contract are handled in the same manner as was the original contract.

Equipment

Equipment, like labor, is a difficult cost to control. A time card should be prepared for each piece of equipment. If an employee is always using a piece of equipment—such as a superintendent and his or her truck—the employee's time card may be used in lieu of a time card for the piece of equipment. The equipment time cards are processed in the same manner as the labor time cards.

Equipment may be billed to a job based on the number of hours spent working on the job or the number of days that the equipment is present at the job. When being charged for equipment based on the equipment being at the project, the project manager should make sure that unneeded equipment is returned promptly to reduce equipment costs.

When equipment is charged to a project, the expected cost of the piece of equipment is allocated to the project. It is important to note that the costs being billed to the projects are not the actual costs but the expected or projected average hourly or daily costs for the year. There is a great deal of uncertainty in the expected costs because of the uncertainty in the number of billable hours or days that will occur during the year and the uncertainty in some of the costs. The ownership costs—rent and lease payments, depreciation, taxes, licenses, and insurance—are easily projected; however, the hourly or daily ownership costs are quite uncertain because of the uncertainty in the number of billable hours or

days over which these costs will be recovered. The operation costs—repairs, maintenance, fuel, and lubrication—vary with equipment use and are much more difficult to quantify because they are a function of the conditions under which the equipment is working and may vary from operator to operator. Because of the uncertainty of the expected costs, the cost allocation and projected number of billable hours or days for the year must be reviewed monthly to determine the appropriateness of the expected costs. At the end of the year the allocation of equipment costs should equal the actual costs. If management overallocates costs—the expected costs are too high—this will increase the project costs and may show that a budget item is over budget when all that is happening is the equipment costs have been overallocated. If management underallocates costs—the expected costs are too low—this will decrease the project costs and may show that a budget item is on or under budget when in reality the item is over budget, yet management does not know it because the equipment costs have been underallocated.

Other

Where possible, the other cost type items should have purchase orders and be handled in the same manner as material purchases. However, there are many items—such as utility bills—that cannot be handled in this manner. Bills such as these should be sent to the project manager for approval and cost coding before processing and paying the bill.

Monitoring and Controlling General Overhead Costs

General overhead costs should be handled in the same manner as project costs with the general manager approving the purchase orders and contracts. Like monitoring project costs the general overhead costs should be compared to a budget on a weekly or monthly basis. The procedures for preparing a general overhead budget are discussed in Chapter 9. Costs that are not actively monitored and controlled will quickly become out of control.

Monitoring Job Profitability

The costs for each job should be monitored at least weekly. During the buyout process—the process of hiring subcontractors and procuring materials—costs are often monitored on a more frequent basis. The monitoring should include monitoring the job costs against a budget as well as updating the cost to complete and the estimated cost at completion for each budget item. All costs should include committed costs. A sample job cost report is shown in Figure 7-4. If the accounting system does not provide a report with committed costs and the estimated cost at completion—as is the case in the job cost report shown in Figure 7-4—these costs should be entered into a spreadsheet similar to the one shown in Figure 4-1.

Job: 317 Weston Apartments — July 16, 2004

Code	Description	Contract Amount	Billed to Date	Costs: Actual	Costs: Budget	Costs: Overrun	Hours: Actual	Hours: Budget	Hours: Overrun
	Phase 1: Bldg 1								
06110	Rough Carpentry	35,000.00	25,000.00	29,375.21	29,200.00	175.21	1,295	1,300	-5
06120	Lumber	42,000.00	39,000.00	36,579.32	37,000.00	-420.68	0	0	0
06150	Trusses	15,000.00	0.00	13,560.00	13,560.00	0.00	0	0	0
	Phase Total	92,000.00	64,000.00	79,514.53	79,760.00	-245.47	1,295	1,300	-5
	Phase 2: Bldg 2								
06110	Rough Carpentry	35,000.00	0.00	11,526.33	29,200.00	-17,673.67	526	1,300	-774
06120	Lumber	42,000.00	0.00	18,265.35	37,000.00	0.00	0	0	0
06150	Trusses	15,000.00	0.00	0.00	13,560.00	-13,560.00	0	0	0
	Phase Total	92,000.00	0.00	29,791.68	79,760.00	-31,233.67	526	1,300	-774
	Job Total	184,000.00	64,000.00	109,306.21	159,520.00	-31,479.14	1,821	2,600	-779

FIGURE 7-4 Sample Job Cost Report

When the estimated cost at completion exceeds the budget for a line item, the project manager should investigate the source of the overrun. Common problem types to look for include clerical errors (such as bills that have been miscoded or incorrectly entered into the accounting system), budgeting and estimating errors, unexpected conditions (such as an unexpectedly cold winter), and poor execution of the work (such as bad planning or poor productivity).

When clerical errors are found they should be sent to the accounting department for correction. After the corrections have been made the cost should be updated to make sure that the correction did not result in any other categories exceeding their budgeted amounts.

When budgeting and estimating errors are found, an internal change order should be issued to move money from the contingency to the category in which the error occurred to maintain a realistic budget for the project. An internal change order is a change order that is not approved by the project's owner because it changes neither the scope nor the cost of the project. Similarly, when a budget category is found to have excess funds during the buyout process, an internal change order should be generated to move the excess funds for the budget line item into the contingency. It is important to have a realistic budget to monitor the progress against. Budgets that have plenty of waste built into them do not require the company to exercise good cost controls. Budgets that have insufficient funds hold employees responsible for meeting costs that they cannot possibly achieve, which often results in the employees becoming demoralized. The budgets should be set at a point where the costs are achievable when good cost control principles are used.

Unexpected conditions do arise, but with careful review of the bid documents and careful planning their impact can be minimized. Many unexpected conditions—such as unexpected ground condition—are billable as a change order to the project's owners. Unexpected conditions should not include winter snow

in an area that is prone to snow during the winter but should be reserved for only those conditions for which there was no way that the conditions could have been foreseen. For example, the snowiest year on record would be an unexpected condition, whereas a winter with an above-average snowfall would not. When truly unexpected conditions occur, the cost of the unexpected conditions should be covered by the contingency or an internal change order should be issued to move money from the contingency to the category that is affected by the unexpected condition to cover the cost of the unexpected condition. Once again it is necessary to maintain a realistic budget for the project. Care must be taken when dealing with unexpected conditions to protect against workers charging all overruns to the unexpected condition regardless of the cause of the overrun.

The final category for cost overruns is poor execution. The execution of the project is wholly within control of the project's management. When a realistic budget has been set for a project, then the cost overruns are due to poor execution and cost underruns are due to good execution on the part of the project's management. The project's management, including the project manager, should be held accountable on a weekly basis for the financial success of the project as well its progress. Not only should they be held accountable for the costs, but also the labor hours, the productivity of the employees, and the schedule for the project. Labor hours should be tracked and recorded in the accounting reports. Good scheduling is a part of controlling costs because schedule overruns increase project costs by increasing project overhead costs, whereas beating the schedule reduces project costs by reducing project overhead costs. A common way of measuring the schedule and the cost efficiency of a project is through the use of earned value. Earned value uses two indexes to measure the performance of a project: the schedule performance index and the cost performance index. Three values are needed to calculate the schedule performance index and the cost performance index. They are the actual cost of the work performed, the budgeted cost of the work scheduled, and the budgeted cost of the work performed.

The actual cost of the work performed comes from the accounting system and represents the actual costs spent on the construction work to a specific date. The actual costs of the work performed should be measured at the same date as the budgeted cost of the work performed and the budgeted cost of the work scheduled. When determining the actual cost of the work performed, cost for work that has not been performed—such as materials whose costs are included in the accounting reports that have not been incorporated into the construction project—should not be included in the costs. Additionally, care must be taken to ensure that costs for all of the completed work are included in the actual costs. Often subcontractors may bill only once a month. If the actual costs are measured between subcontractor's bills, work has been completed by the subcontractor for which the company does not have costs. It is important that the costs are up-to-date for the management to accurately determine the cost performance index.

The budgeted cost of the work scheduled comes from the cost-loaded schedule and is the budgeted or estimated cost for each of the tasks in the schedule that should have been completed or partially completed as of the date selected.

For partially completed tasks the budgeted cost is determined by multiplying the budgeted cost for the task by the task's scheduled percentage of completion. For example, if the task of installing doors has a budget of $5,000 and is scheduled to be 20% complete, then the budgeted cost of the work scheduled for the task is $1,000 ($5,000 × 0.20). It is important to note that the costs used here are budgeted costs, not actual costs.

The budgeted cost of the work performed is determined by taking the budget cost from the cost-loaded schedule for each of the activities on the schedule and multiplying them by their percentage of completion as of the date selected. Again, it is important to note that the costs used here are budgeted costs, not actual costs.

Before we can calculate the schedule performance index and cost performance index we must know how to prepare a cost-loaded schedule.

Cost-Loaded Schedule

A cost-loaded schedule is a schedule that shows not only the time frame when a task is to be completed but also the cost of the work so that the cost of the work completed each week or month can be estimated. A cost-loaded schedule is prepared by first preparing a schedule for the project and then assigning dollar estimates to each of the tasks. The costs for each task are spread out over the duration of the task, resulting in a daily, weekly, or monthly cost for each of the tasks. Scheduling packages, such as Microsoft Project, spread the costs equally over the duration of the task. If the task is scheduled in days, the cost is spread over the days the task is being performed and ignores nonworking days (holidays and weekends). The weekly or monthly costs for a task can be calculated by summing the daily costs. The choice to use days, weeks, or months depends on how often we want to monitor the project. The total cost of the work performed for each week or month may be obtained by adding up the weekly or monthly costs for each of the individual tasks.

Example 7-1: Determine the estimated cost of the work performed each week given the tasks—with their associated costs and schedules—shown in Table 7-1. When a task spans more than one week the costs should be divided equally among the weeks.

Solution: During Week 1, mobilization and grubbing will be completed at a cost of $7,000 ($2,000 + $5,000). During Week 2, bridge excavation, installation of the prefabricated bridge, and back filling the bridge will be completed at a cost of $51,000 ($2,000 + $47,000 + $2,000). The costs to rough excavate the roadway must be equally spread out over Weeks 3 through 6 for a cost of $28,000 ($112,000/4) per week. During Week 3 the installation of the culvers will occur and the rough excavation of the roadway will begin at a cost of $38,000 ($10,000 + $28,000). The remaining weeks are calculated in a similar manner and are shown in Table 7-2.

TABLE 7-1 Schedule and Costs for Example 7-1

TASK	COST ($)	WEEK	
		START	FINISH
Mobilization	2,000	1	1
Grubbing	5,000	1	1
Bridge Excavation	2,000	2	2
Install Prefabricated Bridge	47,000	2	2
Back Fill Bridge	2,000	2	2
Install Culverts	10,000	3	3
Rough Excavate Roadway	112,000	3	6
Install Sanitary Sewer	57,000	6	7
Install Water Lines	69,000	7	8
Install Storm Drains	15,000	8	8
Grade and Roll Sub Grade	12,000	8	9
Place and Compact Road Base	42,000	9	9
Place and Compact Asphalt	48,000	9	9
Grade Shoulders	3,000	10	10
Clean Up	1,000	10	10
Demobilize	2,000	10	10

TABLE 7-2 Cost-Loaded Schedule for Example 7-1

WEEK	COST ($)	WEEK	COST ($)
1	7,000	6	56,500
2	51,000	7	63,000
3	38,000	8	55,500
4	28,000	9	96,000
5	28,000	10	6,000

A cost-loaded schedule may be developed in a scheduling software package such as Microsoft Project or SureTrak. A cost-loaded schedule may also be developed in Microsoft Excel as shown in Figure 7-5.

Schedule Performance Index

The schedule performance index (SPI) measures the success of a project's management to complete the work on time. The schedule performance index is based on the relationship between the budgeted cost of the work performed (BCWP) and the budgeted cost of the work scheduled (BCWS) using the following formula:

$$SPI = BCWP/BCWS \quad (7\text{-}1)$$

Task	Cost	Start	Finish	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Mobilization	2,000	Week 1	Week 1	2,000									
Grubbing	5,000	Week 1	Week 1	5,000									
Bridge Excavation	2,000	Week 2	Week 2		2,000								
Install Prefabricated Bridge	47,000	Week 2	Week 2		47,000								
Back Fill Bridge	2,000	Week 2	Week 2		2,000								
Install Culverts	10,000	Week 3	Week 3			10,000							
Rough Excavate Roadway	112,000	Week 3	Week 6			28,000	28,000	28,000	28,000				
Install Sanitary Sewer	57,000	Week 6	Week 7						28,500	28,500			
Install Water Lines	69,000	Week 7	Week 8							34,500	34,500		
Install Storm Drains	15,000	Week 8	Week 8								15,000		
Grade and Roll Sub Grade	12,000	Week 8	Week 9								6,000	6,000	
Place and Compact Road Base	42,000	Week 9	Week 9									42,000	
Place and Compact Asphalt	48,000	Week 9	Week 9									48,000	
Grade Shoulders	3,000	Week 10	Week 10										3,000
Clean Up	1,000	Week 10	Week 10										1,000
Demobilize	2,000	Week 10	Week 10										2,000
	429,000			7,000	51,000	38,000	28,000	28,000	56,500	63,000	55,500	96,000	6,000

FIGURE 7-5 Cost-Loaded for Example 7-1

If the budgeted cost of the work performed is greater than the budgeted cost of the work scheduled, more work—as measured by budgeted costs—has been performed than was scheduled and the corresponding schedule performance index is greater than one, indicating that the project is ahead of schedule. A schedule performance index of one indicates that the project is on schedule and a schedule performance index of less than one indicates that the project is behind schedule. The strength of the schedule performance index is that it takes all tasks with costs into account when determining if the project is on schedule, not just those tasks on the critical path. When measuring a project's progress using the critical path, it is possible to be on schedule with the tasks on the critical path while ignoring all tasks that are not on the critical path until they become critical. Using the schedule performance index does not allow noncritical tasks to be ignored. The weakness of the schedule performance index is that it does not take into account if the project's critical path is on schedule. It is possible to have a schedule performance index greater than one while being behind on the critical path. Another weakness of the schedule performance index is that it ignores tasks that have a budgeted cost of zero, such as tasks dealing with submittals and the ordering of materials. Because of these reasons the schedule performance index should be used in conjunction with the critical path to determine the success of a project's management to complete the work on time.

Example 7-2: A project consists of three tasks. Task A is scheduled to begin at the start of Week 1 and finish at the end of Week 2. Task B is scheduled to begin at the start of Week 1 and finish at the end of Week 1. Task C is scheduled to begin at the start of Week 2 and end at the end of Week 2. The budgeted cost for Task A is $3,000, for Task B is $1,000, and for Task C is $500. At the end of the first week Task A is 45% complete, Task B is 100% complete, and Task C is 10% complete. What is the schedule performance index for the project at the end of the first week?

Solution: For tasks that are scheduled to be in progress, the budgeted cost of the work scheduled must be prorated. Task A should be 50% complete at the end of the first week; therefore, its budgeted cost of the work scheduled is $1,500 ($3,000 $\times$ 0.50). The budgeted cost of the work scheduled for Task B is 100% of its costs because it was to be completed by the end of the first week. The budgeted cost of the work scheduled for Task C is zero because it was not scheduled to be started by the end of the first week. The budgeted cost of the work scheduled for the project is as follows:

$$\text{BCWS} = \$1{,}500 + \$1{,}000 + \$0 = \$2{,}500$$

The budgeted cost of the work performed is calculated by taking the budgeted cost of the work for each task and multiplying it by the percentage of completion for the task as follows:

$$\text{BCWP} = \$3{,}000(0.45) + \$1{,}000(1.00) + \$500(0.10) = \$2{,}400$$

The schedule performance index is calculated using Eq. (7-1) as follows:

$$SPI = \$2{,}400/\$2{,}500 = 0.96$$

The project is behind schedule.

Cost Performance Index

The cost performance index (*CPI*) measures the success of the project's management to complete the work under budget. The cost performance index is based on the relationship between the budgeted cost of the work performed (*BCWP*) and the actual cost of the work performed (*ACWP*) using the following formula:

$$CPI = BCWP/ACWP \tag{7-2}$$

The actual cost of the work performed is obtained from the accounting system.

If the budgeted cost of the work performed is greater than the actual cost of the work performed, the anticipated cost of the work performed is greater than the actual cost of the work and the corresponding cost performance index is greater than one, indicating that the project is under budget. A cost performance index of one indicates that the project is on budget, and a cost performance index of less than one indicates that the project is over budget.

Example 7-3: The actual cost of the work performed at the end of the first week for the project in Example 7-2 is $2,350. Determine the cost performance index for the project.

Solution: The cost performance index is calculated using Eq. (7-2) as follows:

$$CPI = \$2{,}400/\$2{,}350 = 1.02$$

The project is under budget.

One of the weaknesses of the cost performance index is that it cannot be calculated until all the costs for a specific period have been entered into the accounting system. Because some bills are submitted late, it is hard to get the actual cost of the work performed current to a specific date without including costs that have occurred after that date. This makes it hard to get a fair comparison between the budgeted costs of the work performed and the actual costs of the work performed. Because suppliers and subcontractors often submit their bills only once a month, the cost performance index can only be calculated monthly, limiting its use as a cost control tool.

One way to improve cost control is to look only at the in-house labor, which is often the hardest cost to control. Because our accounting system is tracking the costs of labor on a weekly basis, we can compare the budgeted cost of the labor performed (BCLP) with the actual cost of the labor performed (ACLP) in the same manner that we compared the actual and budgeted costs of the work performed,

thereby creating a labor cost performance index (LCPI). The labor cost performance index is calculated as follows:

$$LCPI = BCLP/ACLP \quad (7\text{-}3)$$

Like the cost performance index, a labor cost performance index greater than one indicates that the labor costs are under budget; a labor cost performance index of one indicates that the labor costs are on budget; and a labor cost performance index less than one indicates that the labor costs are over budget. The weakness of the labor cost performance index is that it ignores materials, subcontractor, and equipment costs.

Example 7-4: For Example 7-2, the budgeted labor cost for Task A is $1,000, Task B is $500, and Task C is $500. The actual labor cost at the end of Week 1 are $950 for all three tasks. Using the information from Example 7-2, determine the labor cost performance index for the project.

Solution: From Example 7-2, Task A is 45% complete, Task B is 100% complete, and Task C is 10% compete. The budgeted cost of labor performed is calculated as follows:

$$BCLP = \$1{,}000(0.45) + \$500(1.00) + \$500(0.10) = \$1{,}000$$

The labor cost performance index is calculated using Eq. (7-3) as follows:

$$LCPI = \$1{,}000/\$950 = 1.05$$

The labor costs are under budget.

The cost performance index may be used to determine the estimated cost at completion for a project or task that is in progress using the following formula:

$$\text{Total Estimated Cost at Completion} = \text{Total Estimate}/CPI \quad (7\text{-}4)$$

The underlying assumption is that the cost performance index will remain the same throughout the remainder of the project or task. This may or may not be true. If the cost performance index is below one, management should take corrective action and improve the cost performance index. The total estimated cost at completion may then be used to determine the cost to complete by subtracting the actual costs to date from the total estimated cost at completion.

Example 7-5: Determine the total estimated cost at completion and estimated cost to complete for the project in Example 7-4, assuming the cost performance index remains the same through the remainder of the job.

Solution: The total estimated cost is $4,500 ($3,000 + $1,000 + $500). The total estimated cost at completion is calculated using Eq. (7-4) as follows:

$$\text{Total Estimated Cost at Completion} = \$4{,}500/1.02 = \$4{,}412$$

The cost to complete is $2,062 ($4,412 − $2,350).

Target Levels for CPI and SPI

What are the best target levels for the cost performance index and the schedule performance index? One would think that the higher the number for these indices the better; however, a high number for either of these indices probably indicates that either the schedule or the budget was unrealistic. For example, a cost performance index of two would indicate that the actual cost of the work performed was half of the budgeted cost of the work performed. It is unlikely that the cost savings of 50% was solely a result of good cost management on the project but instead was a result of an unrealistically high budget. When analyzing the cost performance index and the schedule performance index, management should look at two things: the value of the indices and the trend in these values.

On a project, the costs may be deterministic or probabilistic. The deterministic costs are those costs that management can determine before they occur. Fixed prices from subcontractors, where there is little chance that the cost will change, are considered deterministic costs. Deterministic costs include all committed costs. Probabilistic costs are those costs that management cannot determine before they occur, such as is the case with in-house labor. Probabilistic costs may be represented by a statistical curve such as the normal or bell curve. Although these costs are unknown through analysis of historical data, an expected value and a standard deviation may be determined for each of the costs, provided there is sufficient information. The expected value is the most likely value—in the case of the normal distribution is equal to the mean or average with it being equally likely that the actual cost will exceed the expected value as it is that the actual costs will be less than the expected value. Although the costs are not known they are expected to fall within the distribution curve. The standard deviation represents how much the actual costs could vary from the expected costs. By nature all durations on the schedule are probabilistic.

The ideal target range for the cost performance index and the schedule performance index is within one standard deviation of the expected values. Projects that are between one and two standard deviations from the expected values should be a cause for concern and projects that are more than two standard deviations from the expected values need immediate attention from management. One would expect that a project that consists of mostly deterministic costs would stay closer to the expected values than would a project consisting of mostly probabilistic costs. Because of this it is impossible to set a single target range for all projects.

If the budget and schedule used for the cost performance index and the schedule performance index are based on the expected values then the cost performance index and schedule performance index should be within one standard deviation for both indices. If the indices are based on another value—for example, the costs may be set at a level where the probability of exceeding the costs is 25%—the indices should be within one standard deviation of the index values that represent the expected values. For example, if the costs were set at the level

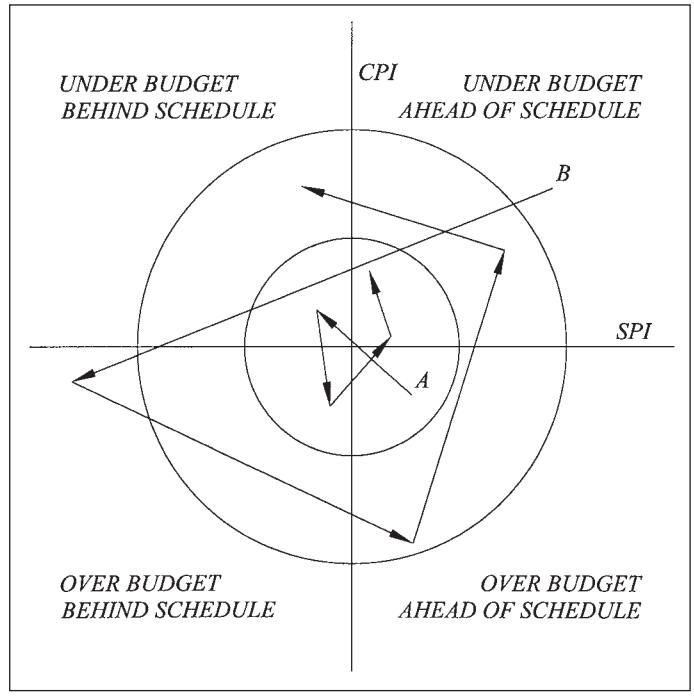


FIGURE 7-6 Graphing the CPI and SPI

where the probability of exceeding the costs is 25%, both indices should be centered around a cost performance index and a schedule performance index greater than one. Determining the standard deviation for the cost performance index and the schedule performance index is beyond the scope of this book.

The second measure that management should look at when using the cost performance and schedule performance indices is the trend of these indices over time. To do this, the indices may be graphed with the *x* axis representing the schedule performance index and the *y* axis representing the cost performance index as shown in Figure 7-6.[31] In Figure 7-6 the inner circle represents one standard deviation from the expected values of one for both the cost performance index and schedule performance index. The outer circle represents two standard deviations. A project that has a high degree of consistency in its schedule performance and cost performance indices is being managed in a more consistent manner and is more likely to stay in control than a project whose indices vary widely from period to period. In Figure 7-6 Project A is in better control and more

[31]See Hemsath, James R., PE and Ra, Dr. Jang W., *Multiple Project Performance with Graphical Performance Indicators,* 46th Annual Meeting of AACE International, June 2002.

likely to stay within the inner circle than Project B, which is all over the place—sometimes ahead of schedule and other times behind schedule—sometimes under budget and other times over budget.

Project Closeout Audit

At the completion of every project—after all the costs and revenues have been recorded—it is important to perform a project closeout audit. The purpose of the project closeout audit is to identify those things that helped to control costs so that they may be repeated on other projects and to identify problems that were encountered so that management can find ways to avoid these problems in the future. It is important that the project closeout audit focuses on finding and fixing problems rather than blaming people. If the project closeout audit becomes a blame-placing game, personnel will hide the problems rather than identify the problems and find ways to avoid them in the future. Project teams need to learn from their mistakes and learn what works well so that it can be repeated. The employees of a company cannot move down the learning curve if they do not learn from their mistakes.

The project closeout audit consists of three steps. First, the project costing data must be validated. This validation includes looking at the cost data in detail and verifying that the costs were charged to the appropriate project and category and that all costs are included. If the project manager has been approving the costs throughout the project, there should be very few problems with inaccurate data. Inaccurate data may cause problems to go unidentified and then lead to erroneous results. Additionally, the project data needs to be correct because historical costs are used to prepare future bids. If the project costs are inaccurate, bids and budgets for future jobs will be inaccurate, which leads to poor job cost controls on future jobs. Realistic and accurate budgets are a must for a strong job cost control system. Second, management must look at those areas of the project where they performed better than expected—the areas where they really shone—and determine what factors led to their success. Once they have identified these factors they should look at ways to incorporate these factors in all of their projects. For example, if they found that holding weekly subcontractor meetings on the job reduced the conflicts on the job and helped coordinate the schedule, they should look at holding weekly subcontractor meetings on all of their projects. Third, management must look at those areas of the project where they encountered problems. When identifying the problems, management should identify the source of the problem. Was the problem a result of problems with the estimate or buyout? Was it the result of a management decision? Was it due to poor project management? Poor production? Excessive waste? Once it has identified the problems it can explore ways to avoid these problems in the future. For example, if management found that doors were not ordered on time—causing construction delays and cost overruns—it could make sure that ordering doors is included as a task on the schedule for future projects. Project teams who do not review and learn from their past projects are condemned to repeat their mistakes.

Conclusion

To manage construction costs appropriate cost control procedures need to be implemented. When controlling costs, the earlier in the process the costs can be checked and approved against a budget the easier it is to control costs. For most material purchases, the purchase should be approved by a purchase order before the materials are ordered. Costs should be entered into the accounting system as soon as possible after the costs are known. For subcontracts and most material purchases the costs should be entered as committed costs shortly after the contract or purchase order is issued. By doing so accurate, up-to-date cost information is maintained in the accounting system. At a minimum, the cost reports from the accounting system should be reviewed on a weekly basis for all projects and for the general overhead. In addition to using accounting reports, earned value may be used to measure the scheduling and cost efficiency of a project. The schedule performance index is used to measure the scheduling efficiency and the cost performance index is used to measure the cost efficiency of the project. At the completion of each project, management should perform a project close-out audit, during which time it learns from what was done right and from its mistakes.

Problems

1. Determine the estimated cost of the work performed each week given the tasks—with their associated costs and schedules—shown in the following table. When a task spans more than one week, the costs should be divided equally among the weeks.

		Week	
Task	Cost ($)	Start	Finish
Mobilization	1,000	1	1
Grubbing	4,000	1	1
Rough Excavate Roadway	24,000	2	4
Grade and Roll Sub Grade	1,000	4	4
Place and Compact Road Base	8,000	5	5
Place and Compact Asphalt	12,000	5	5
Grade Shoulders	1,000	6	6
Clean Up	1,000	6	6
Demobilize	1,000	6	6

2. Determine the estimated cost of the work performed each week given the tasks—with their associated costs and schedules—shown in the following

table. When a task spans more than one week, the costs should be divided equally among the weeks.

Task	Cost ($)	Week	
		Start	Finish
Excavation	2,200	1	1
Footings and Foundation	19,600	2	3
Waterproofing	900	3	3
Backfill and Under Slab Gravel	2,000	4	4
Slab on Grade	22,300	4	4
Masonry	54,000	5	7
Structural Steel	2,400	8	8
Joist and Deck	11,900	8	8
Hollow Metal Doors and Hardware	2,100	9	9
Overhead Doors	10,100	9	9
Skylights	5,800	9	9
Roof Insulation	5,600	10	10
Membrane Roofing	13,000	10	10
Heating	15,600	11	11
Electrical	29,800	11	12
Cleanup	1,000	12	12

3. A project consists of three tasks. Task A is scheduled to begin at the start of Week 1 and finish at the end of Week 3. Task B is scheduled to begin at the start of Week 1 and finish at the end of Week 2. Task C is scheduled to begin at the start of Week 2 and end at the end of Week 3. The budgeted cost for Task A is $22,000, for Task B is $17,000, and for Task C is $15,000. At the end of the second week Task A is 65% complete, Task B is 95% complete, and Task C is 60% complete. What is the schedule performance index for the project at the end of the second week?
4. A project consists of six tasks. Task A is scheduled to begin at the start of Week 1 and finish at the end of Week 4. Task B is scheduled to begin at the start of Week 1 and finish at the end of Week 2. Task C is scheduled to begin at the start of Week 3 and end at the end of Week 4. Task D is scheduled to begin at the start of Week 1 and end at the end of Week 1. Task E is scheduled to begin at the start of Week 2 and end at the end of Week 4. Task F is scheduled to begin at the start of Week 4 and end at the end of Week 4. The budgeted cost for Task A is $10,000, for Task B is $2,000, for Task C is $3,000, for Task D is $1,000, for Task E is $6,000, and for Task F is $4,000. At the end of the third week Task A is 80% complete, Task B is 100% complete, Task C is 40% complete, Task D is 100% complete, Task E is 55% complete, and Task F has not started. What is the schedule performance index for the project at the end of the third week?

5. The actual cost of the work performed at the end of the second week for the project in Problem 3 is $37,900. Determine the cost performance index for the project.
6. The actual cost of the work performed at the end of the third week for the project in Problem 4 is $16,500. Determine the cost performance index for the project.
7. Determine the total estimated cost at completion and estimated cost to complete for the project in Problem 5, assuming the cost performance index remains the same through the remainder of the job.
8. Determine the total estimated cost at completion and estimated cost to complete for the project in Problem 6, assuming the cost performance index remains the same through the remainder of the job.
9. Set up a spreadsheet to solve Problem 1.
10. Set up a spreadsheet to solve Problem 2.