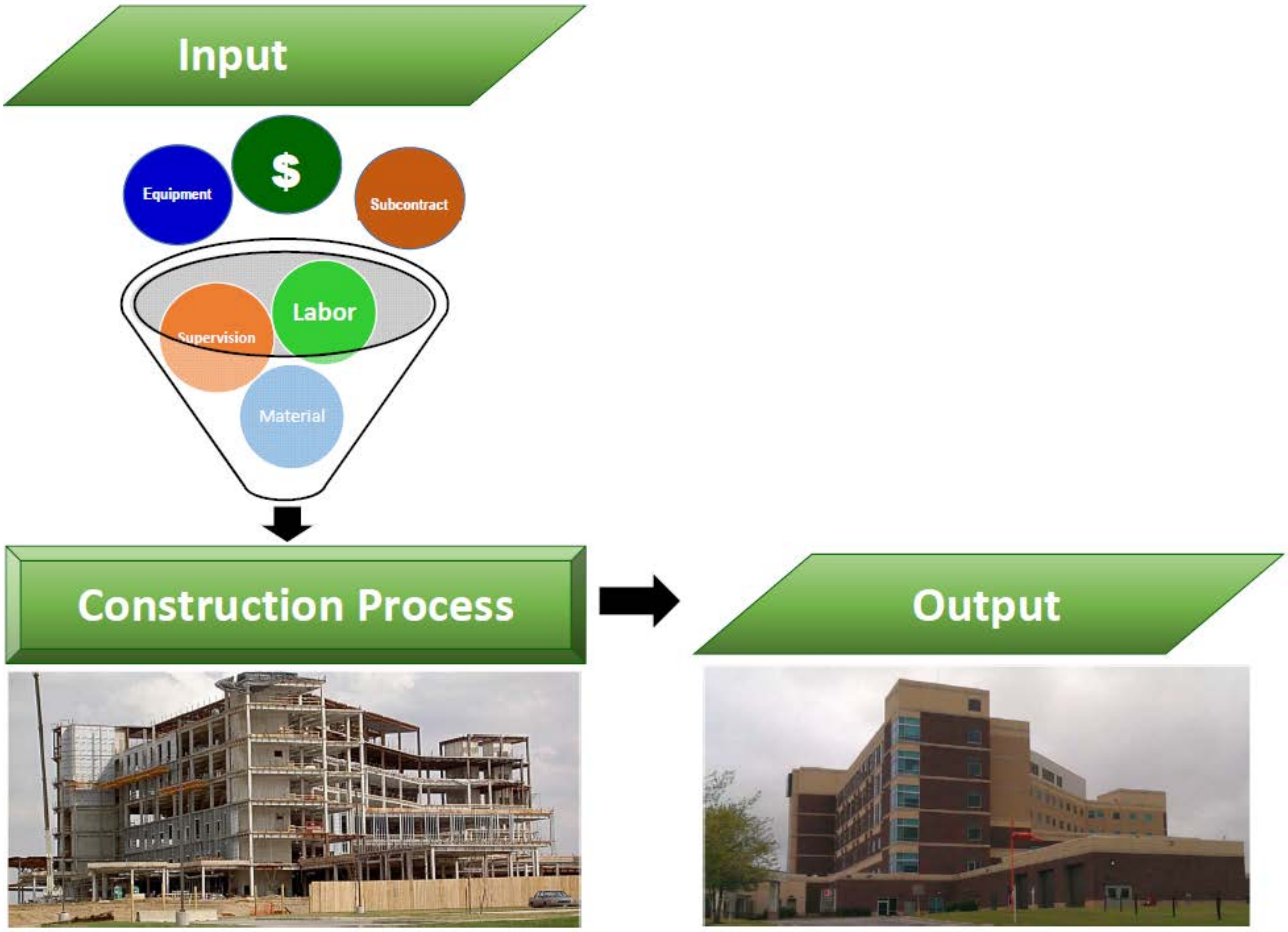

Construction Project Cost Control

By Joe Orczyk

May 2018

Preface

The purpose of *Construction Project Cost Control* is to present techniques that help the contractor to control the cost of the required inputs to the construction process. Every member of the construction project team must work together to control costs. The individual's ability to control construction project costs determines career success in the construction industry. See Jim's story below.

> They tell the story of a small construction company, just like any of the small construction companies you'll find in the USA. This company was owned and managed by a bright young guy who was labeled by one and all as a comer - a guy with lots of promise - because he had a head for figures, he got along well with people, and he liked to build things. He had a couple of foremen who worked with him steady, and he maintained a small office with a bookkeeper. The bookkeeper kept enough books to keep the IRS happy, but not much more, because the boss - Jim was his name - kept most of the company business in his head. Or if he had any records at all they were stuffed in his billfold or were scratched on envelopes, sales slips, business cards and other scraps of paper that cluttered the dashboard of his pickup. Fortunately, Jim could keep track of things well enough that income kept ahead of outgo, and he met his payroll, paid his other bills, and had enough profit left over for his efforts.
>
> But then things got a little tight. Construction started slowing down. The profit margins were getting a little slimmer. Bids were getting closer to the break-even point. But Jim still had as sharp a pencil as anybody did, and he was still getting the jobs. Trouble was that there weren't any bucks left over to take home - No profit margin. Somebody told Jim he ought to keep records. So when he finished a job he could COMPARE HIS ACTUAL COSTS WITH HIS ESTIMATED COSTS - the estimate he used to figure the bid on. Then he'd know where he figured short, and he wouldn't make the same mistake the next time. He ought to set up a reporting system just like the bigger outfits do.
>
> Well, maybe that's what turned him off. He wasn't much for keeping records and filling out report forms, and maybe the big boys could have some fancy reporting system, but he had only one person in the office that was busy keeping the books and answering the phone. Jim is on steady at the mill now - Working for somebody else - Too bad. For a while it looked as if he'd do real well in the construction business.

This passage was adapted from the AGC's Supervisory Training Program (1977).

This book has been developed over a period of years and is being continuously improved. You are encouraged to contact the author at orczykj@purdue.edu with any questions you have about the text and to report any errors.

Table of Contents

Chapter 1
Introduction

Overview

The purpose of this chapter is to define the underlying concepts of construction cost control. These concepts must be understood before specific techniques can be understood. Construction cost knowledge and skills are required by every member of the construction project team. The individual's ability to control project costs determines career success in the construction industry.

Chapter Objectives

Upon completion of this chapter the reader will be able to:

- Describe the construction cost control cycle
- Describe the basic construction cost control concept – Actual v. Budget
- Define the construction project resources
- Describe a construction project work breakdown structure (WBS)
- Describe the construction cost control system
- Describe the preconstruction activities (Estimate/Bid/Budget) relationship to construction cost control

Cost Control Overview

Cost Control Cycle

The control of construction costs takes place during every phase of the construction project. See Figure 1-1, Cost Control Cycle. The estimate is generated during the preconstruction phase. The estimate is the yardstick by which actual cost performance is measured. During the construction phase actual costs are collected and compared to the estimate. The variances between the estimate (budget) and the actual costs direct the project management team to the project hot spots. The continuing monitoring of the project costs gives the team feedback on the effectiveness of their efforts.

During the post construction phase the Final Cost report variances are analyzed. The estimates (during the preconstruction phase) of future project are made incorporating the variances caused by inaccurate estimates on prior projects. In the same way project construction procedures are upgraded to prevent future variances caused by inadequate execution in the field.

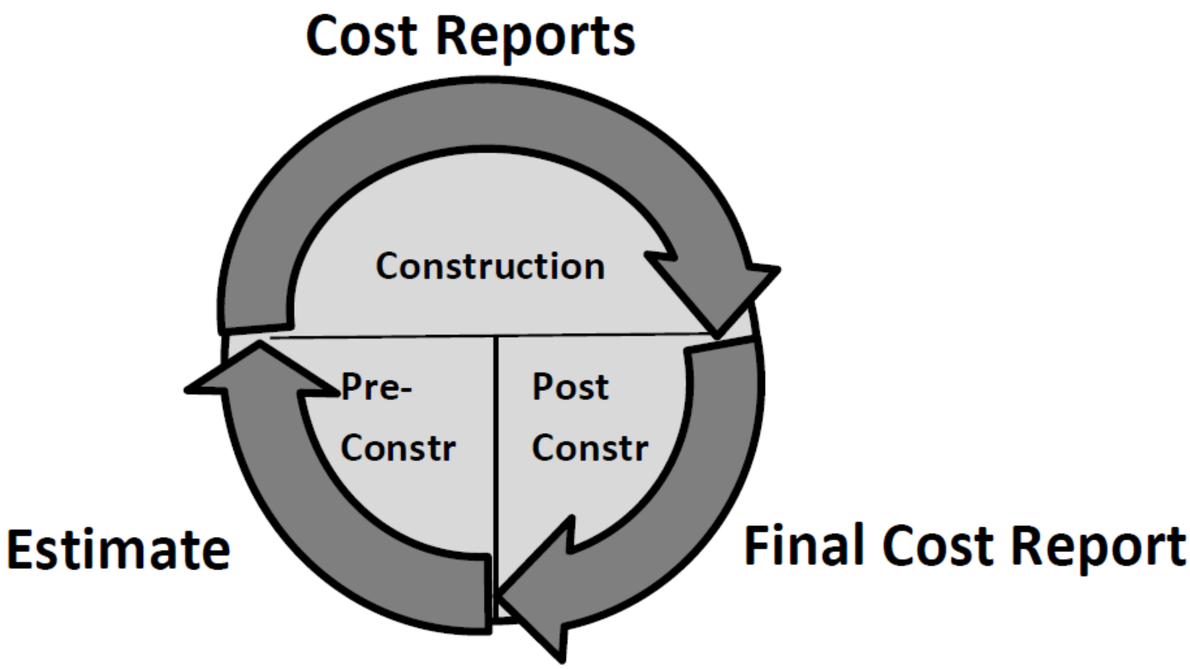

Figure 1-1 Cost Control Cycle

Construction Resources

Construction projects are built by converting resources into structures that satisfies the needs of the owner. The contractor inputs the following resources into the construction process: labor, materials, equipment, and subcontractors. See Figure 1-2, Construction Process. Labor refers to the contractor's employees that install materials to build the project. Labor costs include employee wages and fringe benefits as well as payroll taxes and insurance. Materials are the items the contractor assembles to create the project. Material costs include the purchase price, taxes, and delivery charges. The contractor often arranges for other construction companies (subcontractors), usually specialized craftspeople, to build part of the projects. The cost to the contractor include the subcontract amount plus or minus any changes to the subcontract amount as well as the administrative costs to manage the subcontract. The last major resource is construction equipment. Construction equipment consists of the machines and tools that the contractor's employees use to build the project. Equipment costs include rental charges, maintenance, fuel, insurance, and transportation costs. Grouping costs together by resource is one step in breaking down project construction costs into manageable pieces.

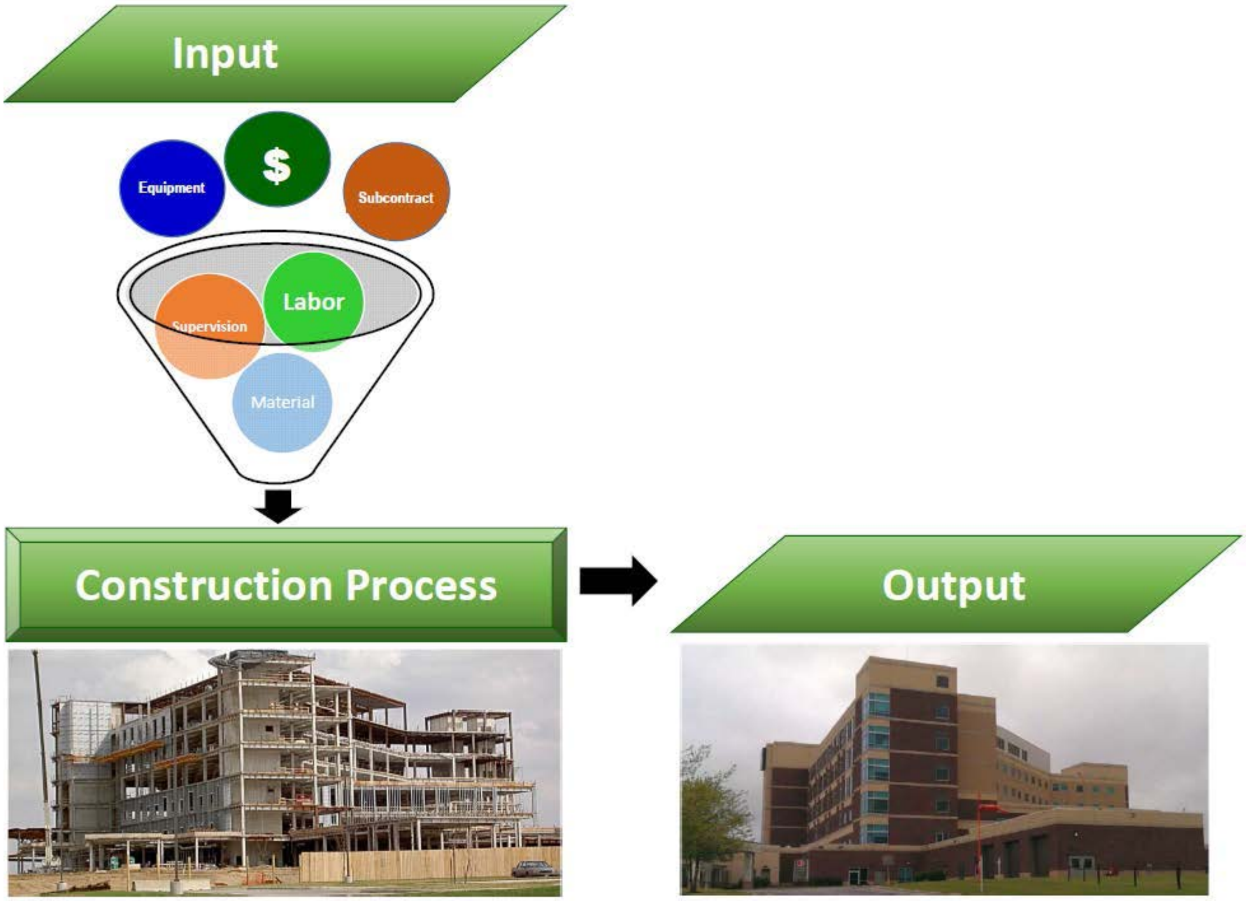

Figure 1-2 Construction Process

Work Breakdown Structure

Grouping costs by resource alone is not sufficient for construction cost control. Costs must be further broken down into controllable parts. This is accomplished using a work breakdown structure. The work breakdown structure is the classification of each project element along activity levels where the activity outputs can be measured and then compared to the resources expended for that activity. Each classification is assigned a cost code for identification purposes. A construction project has hundreds of cost codes. The total number of cost accounts for a project is closely related to the number of line items in the estimate. A study of 30 building contractors in Atlanta showed that for a typical two million-dollar building project the median number of line items in the estimate was 400. (Halpin, 1985) The work breakdown structure must be carefully constructed and documented so that all members of the project team consistently use the correct cost codes for inputs and outputs on every one of the company's projects. This will allow analysis and comparison between projects and help identify trends and variances.

MasterFormat (Construction Specifications Institute, 2012) is the most common construction cost classification system used in building construction. The Construction Specifications Institute (CSI) and the Construction Specifications Canada jointly developed MasterFormat.

MasterFormat is not only used for classifying construction costs, it is also used to organize information in project manuals, for organizing product information, for identifying elements on the drawings, and for presenting construction market data.

MasterFormat is a four level classification system. Level one arranges construction activities into divisions. Each division is further broken down into three more detailed levels. The level one division titles for the 2012 update are listed below:

Construction Specifications Institute MasterFormat 2012 Update - Division Numbers & Titles

GENERAL CONDITIONS SUBGROUP

01 Existing Conditions

FACILITY CONSTRUCTION SUBGROUP

02 Existing Conditions
03 Concrete
04 Masonry
05 Metals
06 Wood, Plastics, and Composites
07 Thermal and Moisture Protection
08 Openings
09 Finishes
10 Specialties
11 Equipment
12 Furnishings
13 Special Construction
14 Conveying Equipment

FACILITY SERVICES SUBGROUP

21 Fire Suppression
22 Plumbing
23 Heating, Ventilating, and Air Conditioning (HVAC)
25 Integrated Automation
26 Electrical
27 Communications
28 Electronic Safety and Security

SITE AND INFRASTRUCTURE SUBGROUP

31 Earthwork
32 Exterior Improvements
33 Utilities
34 Transportation
35 Waterway and Marine Construction

PROCESS EQUIPMENT SUBGROUP

40 Process Integration
41 Material Processing and Handling Equipment
42 Process Heating, Cooling, and Drying Equipment
43 Process Gas & Liquid Handling, Purification, & Storage Equip.
44 Pollution Control Equipment
45 Industry-Specific Manufacturing Equipment
48 Electrical Power Generation

Figure 1-3, Work Breakdown Structure for Plastic Wall Panels, shows a photograph of the top portion of a wall plastic wall panel cladding. These panels provide a good illustration of the application of the work breakdown structure using MasterFormat to a single element of the project.

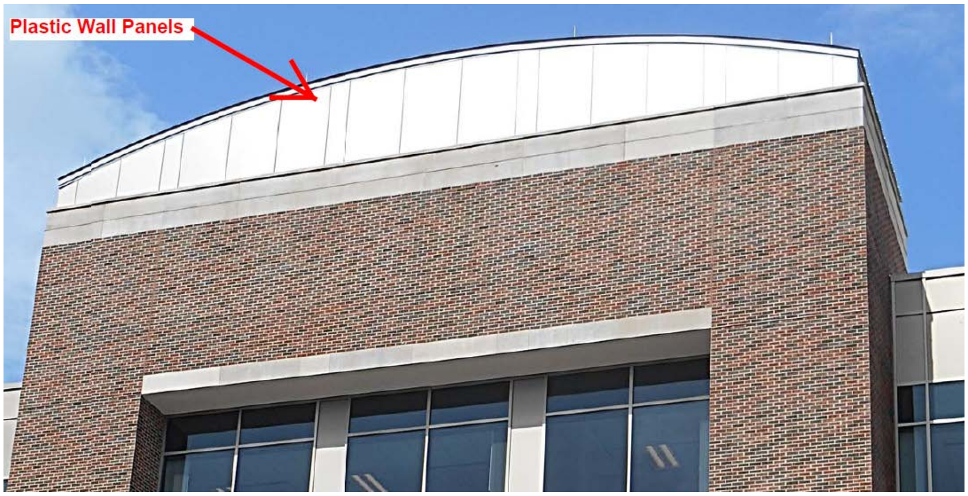

Figure 1-3 Work Breakdown Structure for Plastic Wall Panels

07, Thermal and Moisture Protection MasterFormat Level 1

07 4, Roofing and Siding Panels MasterFormat Level 2

07 42, Wall Panels MasterFormat Level 3

07 42 33, Plastic Wall Panels MasterFormat Level 4

Construction Cost Control System

In general, a control system consists of the element to be controlled, a feedback loop, and corrective action(s). There are various types of control systems. One example of a control system is the heating control system that can be found in a rustic cabin. The wood stove creates heat (corrective action) to maintain the interior temperature (element to be controlled) of the cabin. Feedback is accomplished by the seat-of-the-pants method. When the occupants are cold, they place more firewood in the stove and adjust the dampers. In this control system, there are usually wide swings in the temperature (less control). A more efficient example of a control system is a house with a gas furnace. The heating control system continually monitors the temperature by using a thermostat. The temperature measurement is the feedback portion of the control system. When the house temperature falls below the temperature set by the occupants, a signal is sent to the furnace that turns on the furnace and adds heat to the house until the temperature is at the temperature set by the occupants. Turning on the furnace is the corrective action portion of the control system. In this control system, the occupants achieve more precise control. The efficiency of both the feedback and corrective action determines the overall effectiveness of the control system. See Figure 1-4, Residential Heating Temperature Control System.

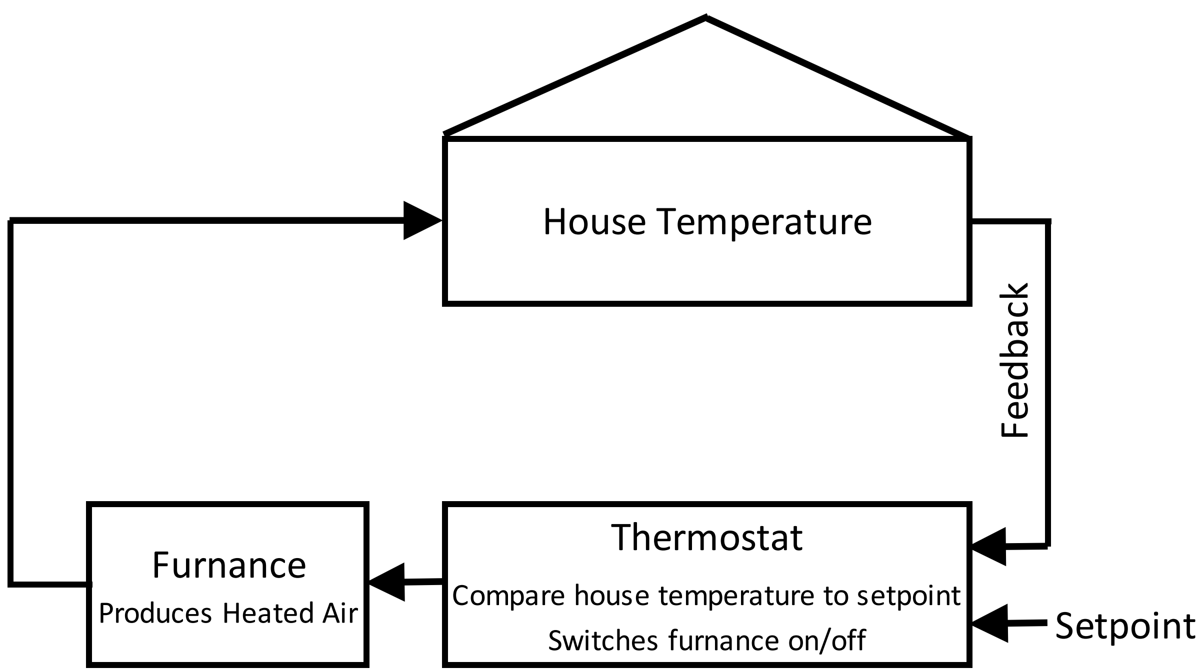

Figure 1-4 Residential Heating Temperature Control System

Control systems are used to manage the costs on construction projects. The element to be controlled is the project cost. Project management gathers actual costs (feedback) and compares them to the project budget. See Figure 1-5, Construction Cost Control Cycle.

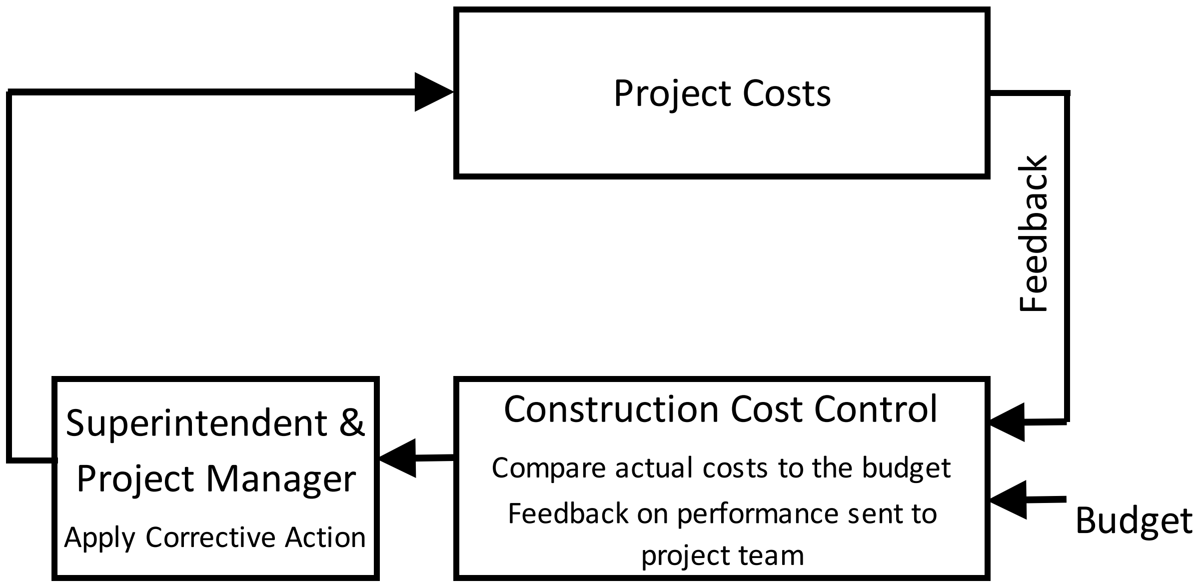

Figure 1-5 Construction Cost Control Cycle

Once deviations are identified, project management must take swift corrective action to minimize cost overruns. In order for these comparison to be accurate there must first be a realistic budget. In measuring length, a ruler that is not exactly 12-inches long is of little use. See Figure 1-6, Inaccurate Budget Cannot Measure True Cost Performance. An inaccurate budget is similarly useless for measuring project cost performance.

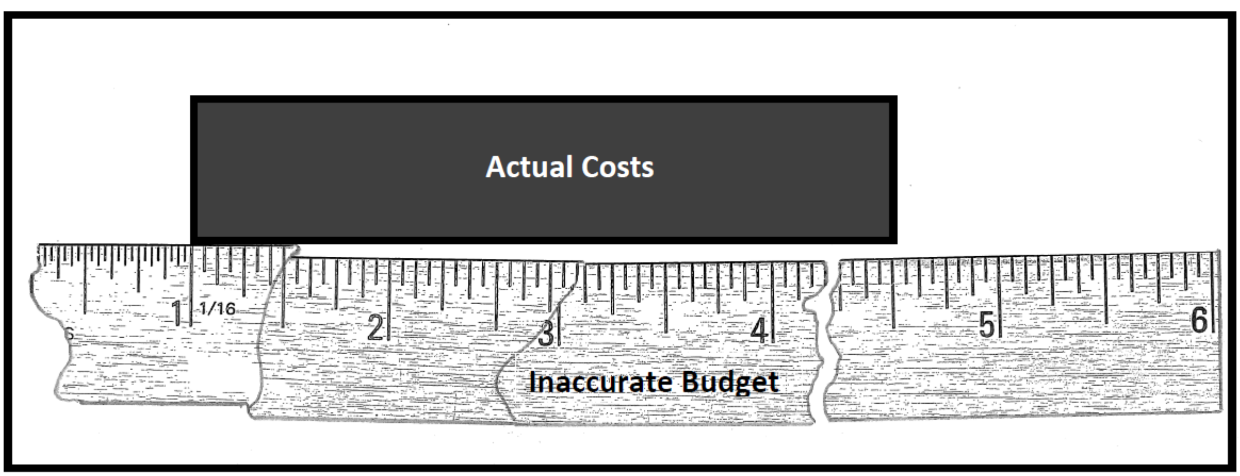

Figure 1-6 Inaccurate Budget Cannot Measure True Cost Performance

Estimate/Bid/Budget - Preconstruction

Overview

A construction project control system needs an accurate budget to be effective. This section will examine how accurate estimates are made and transformed into the project budget. In order to understand the project budget, one needs to be familiar with the estimating process. Note that change order proposals in the field are prepared using the same procedure.

The project bid compiles the estimated cost of each element of the project cost by resource and cost classification (work breakdown structure). The project costs include both the direct project costs and the indirect project costs. The markup portion of the bid includes dollars to cover home office expenses and provide a profit for the construction company. See Figure 1-7, Bid Breakdown.

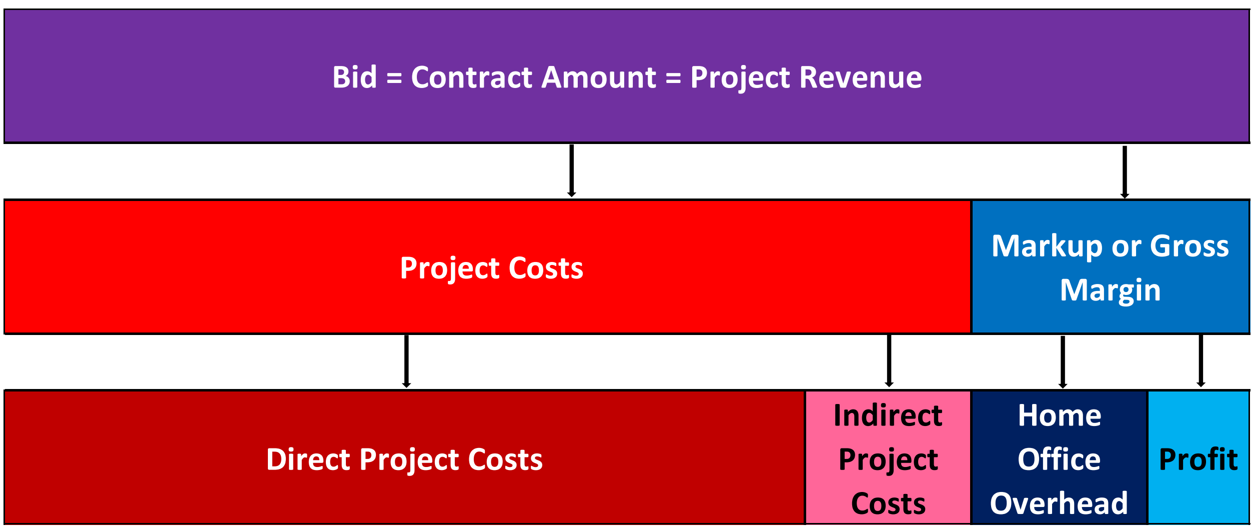

Figure 1-7 Bid Breakdown

All of the MasterFormat divisions are project costs. Project costs are the construction company costs that can be identified with one particular project. There are two types of project costs – direct project costs and indirect project costs (also known as General Conditions Costs). Direct project costs are costs for elements that are identifiable with the finished project. For example, cost code 03 30 00, Cast-in-Place Concrete, represents work that is clearly identifiable with an element of the finished project. On the other hand, cost account 01 50 00, Temporary Facilities and Controls, represents work such as the project office trailer that cannot easily be identified with a specific portion of the finished project. The phrase, “clearly identifiable with an element of the finished project,” is relative. In some companies a great effort is made to identify as many project costs as possible with elements of the finished project (direct costs). Some companies even require the superintendent to report his/her daily work hours by a direct cost category. The most important aspect of construction cost classification within the company is to be consistent from project to project and from department to department.

The mark-up (also known as the gross margin) is the difference between the contract amount and the total project costs. The project manager and superintendent are responsible for maximizing the gross margin for a project. The construction company pools the gross margin for each project. From this pool home office expenses are paid. The money remaining after home office expenses are paid is profit for the company.

Quantity Take-off

So, how are the direct and indirect project costs estimated so that they can be included in the bid summary? Remember that the direct project costs are costs for elements that are identifiable with the finished project. In the estimate all of the project elements are counted and/or measured so that they can later be priced.

A primary attribute of an accurate estimate is the amount of detail. In general, a more detailed take-off results in a more accurate estimate. However, a more detailed the estimate requires a much greater effort in performing the take-off. There is a point of diminishing returns where the effort for more detailed take-offs does not justify the benefits. Therefore, each construction company has developed its own standards for the required level of detail for take-offs.

The estimator can determine the level of detail required for the take-off by examining the unit of measure for the historical unit costs used for the estimate. For example if the suspended ceiling suspension system will be priced using dollars per square feet of ceiling, then the take-off will be in square feet. Note that often the level of detail used for the quantity take-off is not sufficient for purchasing materials. See Figure, 1-8 Take-off Comparison, for a comparison of a bid take-off for a suspended ceiling suspension system and a material take-off for purchasing the suspended ceiling suspension system components for a 40’ by 20’ room.

Description	Unit of Measure	Quantity
Bid Take-off		
Suspended ceiling suspension system	SF	800
Take-off for Purchasing		
12' main runners	Ea	30
4' tee supports	Ea	80
2' tee supports	Ea	160
12' wall molding	Ea	10
Support wire	LF	500
Tie anchors for support wire	Ea	110

Figure 1-8 Take-off Comparison

See Figure 1-9, Foundation Take-off, for an example of a concrete foundation take-off. Only the formwork, concrete, and anchor bolts are shown on this example. Also, the square feet of contact area is abbreviated as SFCA.

Description	Qty	Length LF	Width LF	Depth LF	Formwork SFCA	Concrete CY	Anchor Bolts EA
Spread Footings							
F1	40	4.00	4.00	1.00	640	24	80
F2	30	6.00	6.00	1.33	960	53	120
Spread Footings TOTALS					1,600	77	200
Continuous Footings	1	500.00	2.50	1.00	1,000	46	0

Figure 1-9 Foundation Take-off

Project Estimate

Once the quantities have been taken off, then the estimator must convert the quantities into dollars using unit costs. The unit costs come from historical records of past projects and from vendor quotes for the current project. Figure 1-10, Foundation Estimate, shows the estimate of the example concrete foundation quantity take-off shown in Figure 1-9. Note that there is a $2,000 lump sum vendor quote for all required anchor bolts

Account Number	Description	Quantity	Unit of Measure	Labor $/unit	Labor $	Material $/unit	Material $	Total $
Spread Footings								
031 11 3455	Formwork	1,600	SFCA	$4.00	$6,400	$1.00	$1,600	$8,000
033 10 5724	Place Concrete	77	CY	$30.00	$2,310	$120.00	$9,240	$11,550
032 30 1756	Set Anchor Bolts	200	Ea	$10.00	$2,000	-	-	$2,000
Continuous Footings								
031 11 3450	Formwork	1,000	SFCA	$4.00	$4,000	$3.00	$3,000	$7,000
033 10 5719	Place Concrete	46	CY	$30.00	$1,380	$120.00	$5,520	$6,900
		TOTALS			**$16,090**		**$19,360**	**$35,450**

Figure 1-10 Foundation Estimate

If historical unit prices are used, they must be adjusted to reflect the unique conditions on the project being estimated. The following list contains some of the differences between historical costs and the project being estimated.

- Location
- Size of the project
- Workspace per worker (density)
- Cost escalation due to time
- Site conditions
- Complexity of the design
- Specific requirements of the owner

Vendors and subcontractors will include these conditions on their quotes. The estimator’s task in evaluating and using quotes is scope definition, understanding and documenting exactly what is included and excluded in the quote and then comparing this scope to the drawings and specifications. The following paragraphs discuss the details of pricing the quantity take-off. This discussion will include unit costs, production rates, wage rates and burden, as well as the evaluation of vendor quotes.

Unit Costs

The estimated unit cost is the projected cost, measured in dollars, of a unit of work. In a more general way it is the ratio of the input ($) divided by the output (unit of work), the equations below show the relationship of the unit cost to the production rate for labor costs. The estimated unit cost is the product of the estimated production rate multiplied by the crew wage rate.

$$\text{unit cost} = \frac{\$}{\text{unit}}$$

$$\frac{\$}{\text{unit}} = \frac{\text{workhours}}{\text{unit}} \text{ X } \frac{\$}{\text{workhour}}$$

Production Rates

The production rate is also the ratio of the input divided by the output. Production rates and unit costs are derived from the data on past similar projects. If there is no company historical data for an item of work, then an estimating database like Means will be consulted.

Wage Rates and Burden

The bare labor wage rate is the gross direct wages paid to the worker. In addition to the bare wage rate the employer must also pay the labor burden. The labor burden includes the fringe benefits plus taxes and insurances that the employer pays based on labor payroll. The gross direct wages paid to the worker plus the labor burden equals the burdened labor. Because state taxes and workers compensation insurance rates vary by state, the labor burden varies by state. Also, workers compensation insurance rates vary significantly by company based upon experience modifications. This provides a strong incentive for companies to have safe jobsites. See Figure 1-10, Wage Rate Breakdown, for an example of typical items included in the labor burden.

The crew wage rates for work items vary by the mix of crafts that are included in a crew. The estimate should specify the crew mix used for each line item.

	$/Hour	
Bare Labor Rate:	**$26.00**	
Labor Burden:		
Social security taxes (FICA) 7.65%	**$1.99**	
Federal unemployment insurance (FUI) 3.0%	**$0.78**	
State unemployment insurance (SUI) 3.2%	**$0.83**	
Workers compensation insurance 25%	**$6.50**	
Builders risk insurance 0.50%	**$0.13**	
Public liability insurance 2.00%	**$0.52**	
Fringes: Medical insurance $3.00/hour	**$2.25**	
Total Labor Burden: $ and as % of Bare Labor Rate	**$13.00**	**50.00%**
Burdened Labor Rate:	**$39.00**	

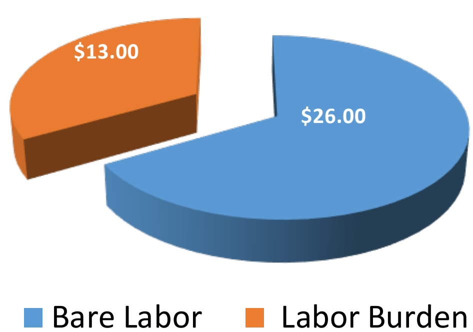

Figure 1-10 Wage Rate Breakdown

Chapter 1 provides important background information. In the following chapters this information will be project cost control techniques.

Summary

This chapter presented the basic concepts of construction cost control. Subsequent chapters will build upon these concepts. The control of construction costs takes place during every phase of the construction project. Construction projects are built by converting the resources of labor, materials, equipment, and subcontractors into structures that satisfies the needs of the owner. Identifying the resources is not sufficient to control construction costs. Cost control happens at a more detailed level. This detail is defined using a work breakdown structure. The work breakdown structure is the classification of each project element along activity levels where the activity outputs can be measured and then compared to the resources expended for that activity.

Control systems are used to manage the costs on construction projects. A control system consists of the element to be controlled, a feedback loop, and corrective action(s). The element to be controlled is the project cost account. Project management gathers actual costs (feedback) for each cost account and compares them to the project budget. Once deviations are identified, project management must take swift corrective action to minimize cost overruns.

The scope of the project is described in detail in the drawings and specifications. Accurate project estimates are created by precisely quantifying all project elements. Once the quantities are available the estimator converts these quantities into dollars using historical unit costs that have been adjusted for the time and place of the project. This estimate, with a few adjustments becomes the project budget.

The project costs are the major portion of the entire contract amount that the owner will pay the contractor. The remaining portion of the contract amount is the mark-up (also known as the gross margin) which helps pay for the contractor’s home office expenses and provides for the contractor’s profit.

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Chapter 2

Project Cash Flow

Overview

It is the project manager's responsibility to ensure that the construction company is paid for all completed work on the project. This chapter will first describe the progress payment process. Then the details of the project cash flow process will be illustrated by creating a cash flow projection for a small project. Finally, guidelines are presented for optimizing the cash flow cycle for the prime contractor.

In order to understand the payment process, the project manager needs to understand the legal principles of progress payments. Legal doctrine does not require progress payments for private work. In fact, legal doctrine holds that the performance of services precedes payment of those services (doctrine of conditions). This protects the party receiving the services by permitting that party to withhold payment until all of the services are performed satisfactorily. This *work first and then be paid* rule places an enormous financial responsibility on the prime contractor. Construction contracts generally provide for periodic progress payments to ease (but not eliminate) this burden on prime contractors. Additionally federal and state laws do require progress payments for most government funded projects and for some privately funded projects.

The project manager's responsibilities include making sure the prime contractor gets paid on time and forecasting the cash flow requirements of the project. The project manager assures that the prime contractor will be paid on time by following all of the pay provisions of the contract, by submitting pay applications on time, and by monitoring prompt payment by the owner or prime contractor. The project manager forecasts the cash flow requirements of the projects by projecting both anticipated progress payments and expenditures for labor, material, equipment, subcontracts, and general condition costs.

Prime contractor and Subcontractor

Note that the term contractor can refer to either a prime contractor or a subcontractor. This chapter discusses both payments from the owner to the prime contractor and payments from the prime contractor to subcontractors. A prime contractor is any contractor on a project having a contract directly with the owner. A subcontractor is a contractor under contract to a prime contractor by subcontract for completion of a portion of the work for which the prime contractor is responsible. These definitions of prime contractor and subcontractor are from the DictionaryOfConstruction.com.

Chapter Objectives

Upon completion of this chapter the reader will be able to:

- Describe the principles underlying progress payments
- Prepare the schedule of values
- Forecast the cash payments for a project – Cash In
- Forecast the cash required to pay all costs for a project – Cash Out
- Forecast the project overdraft – difference between Cash In and Cash Out
- Prepare graphs displaying the project cash flow and the project overdraft
- Recommend actions to improve project cash flow

Construction Pricing Methods –Fixed Price, Cost Plus, and Unit Price

The method of submitting pay applications varies according to the type of construction contract. There are many types of construction pricing methods, the most common are fixed price, cost plus, and unit price. The general procedure for making pay applications for each method is described below. It is important that project managers understand the specific contract pay application provisions for each individual project.

Fixed Price

In a fixed price contract (frequently called "lump sum") the owner and prime contractor agree on a fixed sum for all the work in the project scope. Before the first progress payment application, the prime contractor must provide a breakdown of the contract amount into separate pay items called the schedule of values. This must occur before the first progress payment application. The prime contractor will require this same type of breakdown from its subcontractors. Once approved, the Schedule of Values becomes the basis for progress payments.

At the end of the progress payment period, the prime contractor determines the percent complete for each pay item. This percent is multiplied by the corresponding schedule of value to compute the pay request for that pay item. The prime contractor's total pay request is the sum of each pay item pay request. The owner or their representative verifies the actual percent complete before making payment. See the detailed cash flow plaza project example for a fixed price contract later in this chapter.

Cost Plus

In a cost plus contract (also known as "time and material") the owner agrees to reimburse the prime contractor for all costs of the work on the project. Plus the owner will pay the prime contractor a fee for home office overhead and profit. There are many variations for this type of contract, the most frequent being a “guaranteed maximum” amount that the owner will reimburse the prime contractor. The prime contractor will not be reimbursed for any costs exceeding the guaranteed maximum amount.

The pay request for a time and material contract consists of a detailed accounting of all costs incurred by the prime contractor during the progress payment period for the pay item. The actual costs must be supported by invoices, receipts, and certified payrolls. A portion of the fee is then added to the sum of these costs to determine the pay request. Prime contractors can lose money on cost plus contracts if they are not able to document all the labor, materials, equipment, and subcontractor costs. The owner or their representative verifies the detailed accounting of actual costs before making payment.

Unit Price

A unit price contract consists of a list of unit prices agreed to by both parties. At the end of the progress payment period, the prime contractor determines the quantity completed for each pay item. This quantity is multiplied by the contract unit price to compute the pay request for that pay item. The prime contractor’s total pay request is the sum of each pay item pay request. The owner or their representative verifies the quantities installed before making payment. See Figure 2-1 for an example of a unit price pay application

Pay Items	Unit of Measure	Contract Unit Prices	Verified Quantities This Period	Payment Amount
Clearing and Grubbing	**Acre**	$80,000	0.80	$64,000
Excavation, Common	**CY**	$35.00	4,400	$154,000
Excavation, Rock	**CY**	$75.00	600	$45,000
Compacted Aggregate, No. 53, Base	**Ton**	$30.00	2,500	$75,000
		Total Payment Due		$338,000

Figure 2-1 Unit Price Pay Application

Cash Flow for a Fixed Price Contract

Example Project

An example project is used to illustrate the cash flow concepts described in this chapter. The plaza project example is based on a portion of an actual project, see Figure 2-2. The contract terms, time schedule, and estimated are assumed and are not the data for the actual project.

Assumptions for the plaza project example

- This is a lump sum prime contract
- See Figure 2-3 for the estimated costs, bid, and schedule of values
- See Figure 2-4 for the bar chart schedule
- Seeding & landscaping are subcontracted, all other work is performed by the prime contractor
- Progress billings made at end of weeks # 2 & 6.
- Owner will pay the supplier's invoice amount for materials delivered, but not installed.
- Plaza material is scheduled to be delivered at the end of week #2
- All other materials – concrete , wire mesh, stone, and topsoil – will be delivered the same day they are installed
- Owner makes payments four weeks after the billing
- Owner retains 10% of each payment that is returned after project close-out. Assume that the owner will make the final payment at the end of Week #14

Figure 2-2 Picture of the plaza project example

Schedule of Values

For fixed price contracts, the total contract amount (lump sum) does not provide the detail required to calculate accurate requests for payment as required by the owner. Therefore, most contracts require a breakdown of the contract amount into the schedule of values using language similar to Paragraph 9.2 in the American Institute of Architects (AIA) Document A201 (2017), General Conditions of the Contract for Construction. Paragraph 9.2 states, *"…the Contractor shall submit a schedule of values to the Architect, before the first Application for Payment, allocating the entire Contract Sum to the various portions of the Work. The schedule of values shall be prepared in the form, and supported by the data to substantiate its accuracy required by the Architect. This schedule, unless objected to by the Architect, shall be used as the basis for reviewing the Contractor's Applications for Payment."* Until there is an approved schedule of values, no progress payments will be approved. Owners will approve the schedule of values only if they judge that the value for each work category contains only the prime contractor's estimated cost plus a proportional share of overhead and profit. They will reject the schedule of values if they suspect that the items of work to be completed early in the project contain more than a fair share of overhead and profit (i.e., front-end loading).

The prime contractor will require each subcontractor to submit a schedule of values for the subcontract work. The prime contractor is advised to incorporate the *subcontractor's schedule of values* into the prime contractor's own breakdown. This facilitates the incorporation of the *subcontractor's application for payment* into the prime contractor's application.

Prime contractors often include a mobilization pay item on the schedule of values. Mobilization includes front-end costs such as surety bond premiums, moving-in expenses (trucking, phone installation, etc.), temporary structures (office, storage, fabrication areas, fencing, barricades, and laydown areas), installation of temporary water, and installation of temporary heat equipment. Good documentation of these costs can be used for arguing for the inclusion of the full amount of the mobilization pay item.

Once the categories have been determined, the next step is to assign a dollar value to each category. At the minimum, each category must contain at least the direct cost of doing the work. Otherwise, the prime contractor will need to complete the last items on the project using its own money because the prime contractor will have already received payment for this work.

Some owners and architects are able to accurately estimate the cost of each Schedule of Values category. This is particularly true if the owner had prepared a detailed prebid estimate. With an accurate estimate, the owner can determine the probable cost and markup included with each pay item and identify front end loading. If the original schedule of values is rejected for front-end loading, then subsequent submittals of the schedule of values will likely be scrutinized.

A word of caution: owners have tried to use the schedule of values to determine the value for work deleted or added; this is not the purpose of the schedule of values. Prime contractors should not agree to the use of the schedule of values for this purpose.

Figure 2-3 shows the prime contractor's bid for the plaza project. The estimated total cost of the bid items is $65,000. This amount does include $1,000 for the estimated cost of mobilization. Additionally the prime contractor estimates an additional cost of $3,000 for time dependent general condition costs for project supervision, temporary construction, utilities used during construction, and other general condition costs. Finally the markup (gross margin) is included in the bid amount. The markup for this project contributes towards paying the prime contractor's home office expenses and providing a profit. The prime contractor's bid for the plaza project is $80,000.

For the plaza project example a proportionate amount of the time dependent general condition costs and markup will be added to the estimated total cost of each bid item to calculate the scheduled value for the item. Mathematically this is accomplished by calculation a proportional factor which is the total bid divided by the total cost of the bid items or 1.2308 ($80,000/$65,000). The estimated cost of each bid item is multiplied by this factor to calculate its schedule of value. Note that each value is rounded to the nearest $100.

Item	Labor	Material	Equipment	Subcontract	Bid	Schedule of Values
Mobilization	$1,000				$1,000	$1,200
Site preparation	$4,000		$8,000		$12,000	$14,800
Concrete foundations & sidewalks	$9,000	$9,000			$18,000	$22,200
Plaza equipment	$8,000	$16,000			$24,000	$29,500
Seeding & landscaping (Subcontracted)				$10,000	$10,000	$12,300
Total Cost of Pay Items	$22,000	$25,000	$8,000	$10,000	$65,000	
Time Dependent General Condition Costs					$3,000	*included*
Total Project Costs					$68,000	
Markup (Gross Margin)					$12,000	*included*
Total Bid/Schedule of Values					$80,000	$80,000

Figure 2-3 Bid & Schedule of Values for the Example Project

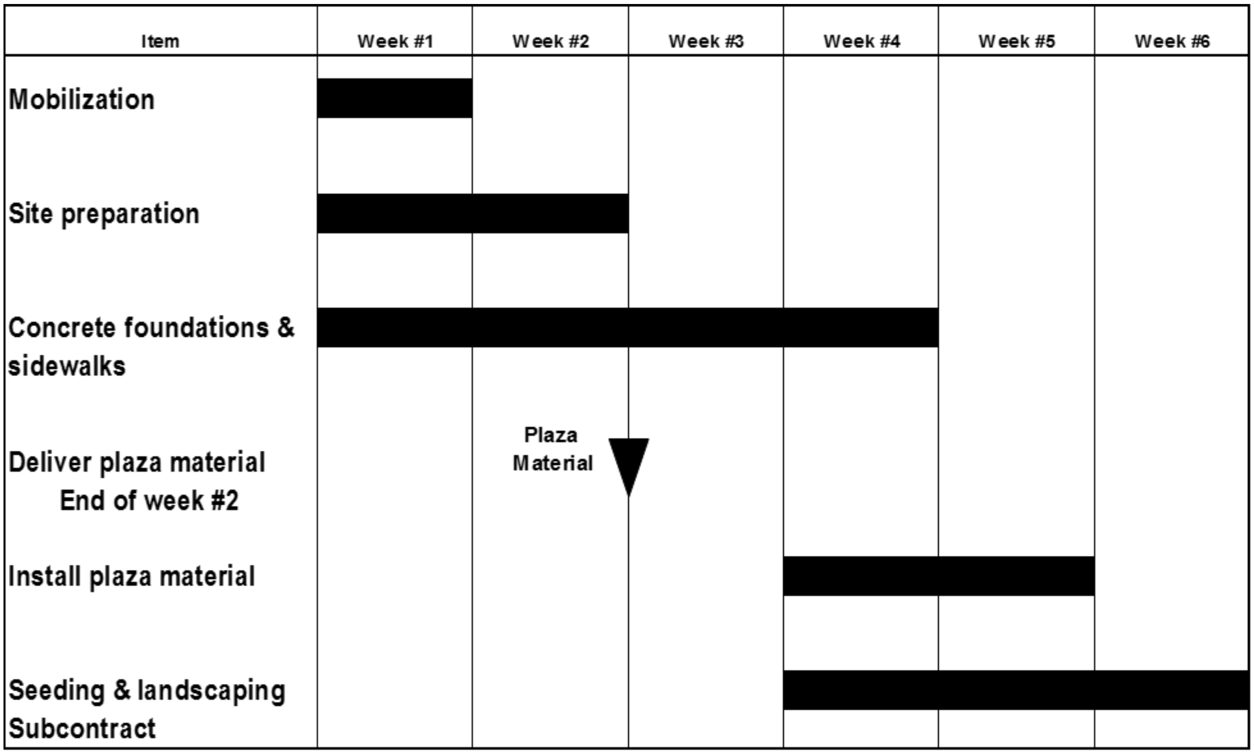

Figure 2-4 Schedule for the Example Project

Pay Requests

The estimate of pay requests for the plaza project are made using the approved schedule of values and the time schedule, Figure 2-4. This time schedule uses a black bar to indicate when the work will be accomplished. Note that except for the plaza material all of the materials – concrete, wire mesh, stone, and topsoil – will be delivered the same day they are installed. The plaza material is scheduled to be delivered at the end of week #2. This date is indicated on the schedule by an inverted triangle.

Pay request #1, Figure 2-5, will include all of the work scheduled to be done by the end of week #2. Mobilization and site preparation will be 100% complete. Assuming that an equal amount of work is scheduled each week, the concrete foundations & sidewalks activity will be 50% complete. The owner will pay the supplier's invoice amount ($16,000) for the plaza materials delivered and stored, but not installed. The total amount of the prime contractor's pay request is $43,100. The owner retains 10% of each payment so the net payment to date is $38,790.

Description of Work	Schedule of Values	Installed To-Date %	Installed To-Date $	Materials Stored - Not Installed $	Installed & Stored To-Date $
Mobilization	$1,200	100.0%	$1,200		$1,200
Site preparation	$14,800	100.0%	$14,800		$14,800
Concrete foundations & sidewalks	$22,200	50.0%	$11,100		$11,100
Plaza equipment	$29,500	0.0%	$0	$16,000	$16,000
Seeding & landscaping (Subcontract)	$12,300	0.0%	$0		$0
Totals	$80,000	-	$27,100	$16,000	$43,100
Less: 10% Retainage					($4,310)
Total Net Payment To-Date					**$38,790**
Less: Previous Payments					$0
Total Net Payment Due					$38,790

Figure 2-5 Pay Request #1

Pay request #2, Figure 2-6, will include all of the work scheduled to be done by the end of week #6. All activities will be 100% complete. The plaza material is now installed so there is no material stored but not installed. The total amount of the prime contractor's pay request is $80,000. The owner retains 10% of each payment so the net payment to date is $72,000. Since $38,790 will be paid as part of pay application #1, this amount is subtracted from the current pay request and the net payment due is $32,210.

Description of Work	Schedule of Values	Installed To-Date %	Installed To-Date $	Materials Stored - Not Installed $	Installed & Stored To-Date $
Mobilization	$1,200	100.0%	$1,200		$1,200
Site preparation	$14,800	100.0%	$14,800		$14,800
Concrete foundations & sidewalks	$22,200	100.0%	$22,200		$22,200
Plaza equipment	$29,500	100.0%	$29,500		$29,500
Seeding & landscaping (Subcontract)	$12,300	100.0%	$12,300		$12,300
Totals	$80,000	-	$80,000	$0	$80,000
Less: 10% Retainage					($8,000)
Total Net Payment To-Date					**$72,000**
Less: Previous Payments					$38,790
Total Net Payment Due					$33,210

Figure 2-6 Pay Request #2

Lag between Doing Work and Receiving Progress Payment

In general, the prime contractor's pay request is submitted at the end of the pay request period. Before issuing a payment certificate, the owner's agent reviews the application and usually visits the site to verify the actual construction progress. The owner's agent will then either certify the application for payment or withhold certification in whole or part. It is common for the owner's agent to certify a lesser amount of one or more categories of the prime contractor's application for payment. Paragraph 9.5.1 of the American Institute of Architects (AIA) Document A201 (2017) lists seven reasons for withholding certification. These reasons are:

1. defective Work not remedied
2. third party claims filed or reasonable evidence indicating probable filing of such claims. Unless security acceptable to the Owner is provided by the Contractor
3. failure of the Contractor to make payments properly to Subcontractors or suppliers for labor, materials or equipment

4. reasonable evidence that the Work cannot be completed for the unpaid balance of the Contract Sum
5. damage to the Owner or a Separate Contractor
6. reasonable evidence that the Work will not be completed within the Contract Time, and that the unpaid balance would not be adequate to cover actual or liquidated damages for the anticipated delay
7. repeated failure to carry out the Work in accordance with the Contract Documents.

When satisfied that the pay request is accurate, the owner or their agent will certify the pay request for payment.

The contract will often stipulate the time period between the pay application cut-off date and the date that payment is due. This time period is frequently one month. See A101-2017 §5.1.3 for example contract language. In addition to this payment lag, the owner retains part of the progress payment as a guarantee that the prime contractor will complete the project and will repair any defective work. Retainage provides money to pay for claims the owner may have against the prime contractor without the expense and bother of a lawsuit. There are several arguments against owners holding retainage. One argument is that performance and payment bonds protect the owner; therefore, retainage is redundant and unnecessary. Subcontractors that finish their work early in the project, such as the site utility subcontractor make another argument. These subcontractors propose that owners use line-item retention. Line item retention would grant the subcontractors the right to receive their retainage when they complete their portion of the work, instead of waiting for the completion of the entire project.

For the plaza project example the owner makes payments four weeks after the billing. Pay Request #1 is submitted at the end of Week #2 and the owner will make the payment at the end of Week #6. Likewise, Pay Request #2 is submitted at the end of Week #6 and the owner will make the payment at the end of Week #10.

Subcontractors submit their pay requests to the prime contractor who then incorporates the subcontractors' requests with the pay request for the prime contractor's work into one pay request for the owner. Many subcontracts have a *paid-when-paid* clause that stipulate the time period between the prime contractor receiving payment from the owner and the prime contractor paying the subcontractor. This time period is frequently seven days. Some prime contractors hold onto the subcontractor's progress payment for an even longer period.

Most subcontracts have *pass through* clauses that require subcontractors to be bound by the progress payment requirements imposed on prime contractors. A typical subcontract payment clause states, *Progress payments to the Subcontractor for satisfactory performance of the Subcontract Work shall be made no later than seven days after receipt by the Contractor of payment for the owner from the Subcontract Work.* This is known as the *paid-when-paid* clause.

This clause is generally enforced by the legal system. However, judges have consistently ruled that if the owner never pays the prime contractor or pays the prime contractor very late, the prime contractor will be required to pay the subcontractor within a reasonable time.

Receiving Final Payment from the Owner

Owners will not make the final payment to the prime contractor until all work described in the contract documents has been completed to the owner's satisfaction. In addition construction lien laws give prime contractors, subcontractors, and suppliers a legal recourse to be paid for their services and materials. If not paid in full prime contractors, subcontractors, and suppliers can file a lien on the owner's property. Owners are obligated to make sure that all parties are paid for improvements to the owner's property. This obligation requires owners to make sure that the subcontractors and suppliers are paid by the prime contractor. Making payments to the prime contractor does not satisfy the owner's obligation. The owner must ensure that the prime contractor pays all parties providing goods and services for the owner's project. If any party is unpaid they have a right to file a lien on the owner's property and the owner is required to pay these subcontractors and suppliers regardless of payments to the prime contractor for this work. Owners require complete documentation from the prime contractor that all bills have been paid in full. Paragraph 9.10 of the American Institute of Architects (AIA) Document A201 (2017) is an example of the owner's requirements for final completion and final payment. Subparagraph 9.10.2 describes the owner's final payment documentation requirements.

> §**9.10.2** Neither final payment nor any remaining retained percentage shall become due until the Contractor submits to the Architect (1) an affidavit that payrolls, bills for materials and equipment, and other indebtedness connected with the Work for which the Owner or the Owner's property might be responsible or encumbered (less amounts withheld by Owner) have been paid or otherwise satisfied, (2) a certificate evidencing that insurance required by the Contract Documents to remain in force after final payment is currently in effect, (3) a written statement that the Contractor knows of no reason that the insurance will not be renewable to cover the period required by the Contract Documents, (4) consent of surety, if any, to final payment, (5) documentation of any special warranties, such as manufacturers' warranties or specific Subcontractor warranties, and (6) if required by the Owner, other data establishing payment or satisfaction of obligations, such as receipts, and releases and waivers of liens, claims, security interests, or encumbrances arising out of the Contract, to the extent and in such form as may be designated by the Owner. If a Subcontractor refuses to furnish a release or waiver required by the Owner, the Contractor may furnish a bond satisfactory to the Owner to indemnify the Owner against such lien, claim, security interest, or encumbrance. If a lien. Claim, security interest, or encumbrance remains unsatisfied after payments are made, the Contractor shall refund to the Owner all money that the Owner may be compelled to pay in discharging the lien,

claim, security interest, or encumbrance, including all costs and reasonable attorneys' fees.

For the plaza project example the prime contractor satisfactorily completes the project and provides all documentation so that the owner makes the final payment of $8,000 at the end of week #14.

Cash In Profile

The cumulative (to-date) cash-in profile displays each progress payment and the cumulative payments to-date. Because payments are received only once a month, this plot is shown with a vertical line representing each forecasted progress payment. Since there is no cash received between progress payments, the cash-in profile is plotted as a horizontal line for the time period between progress payments. Therefore, the cash-in profile results in a stair-shaped shape. For the plaza project example there are two progress payments and the final payment for a total of three vertical lines. See Figure 2-7 for the cumulative cash in profile.

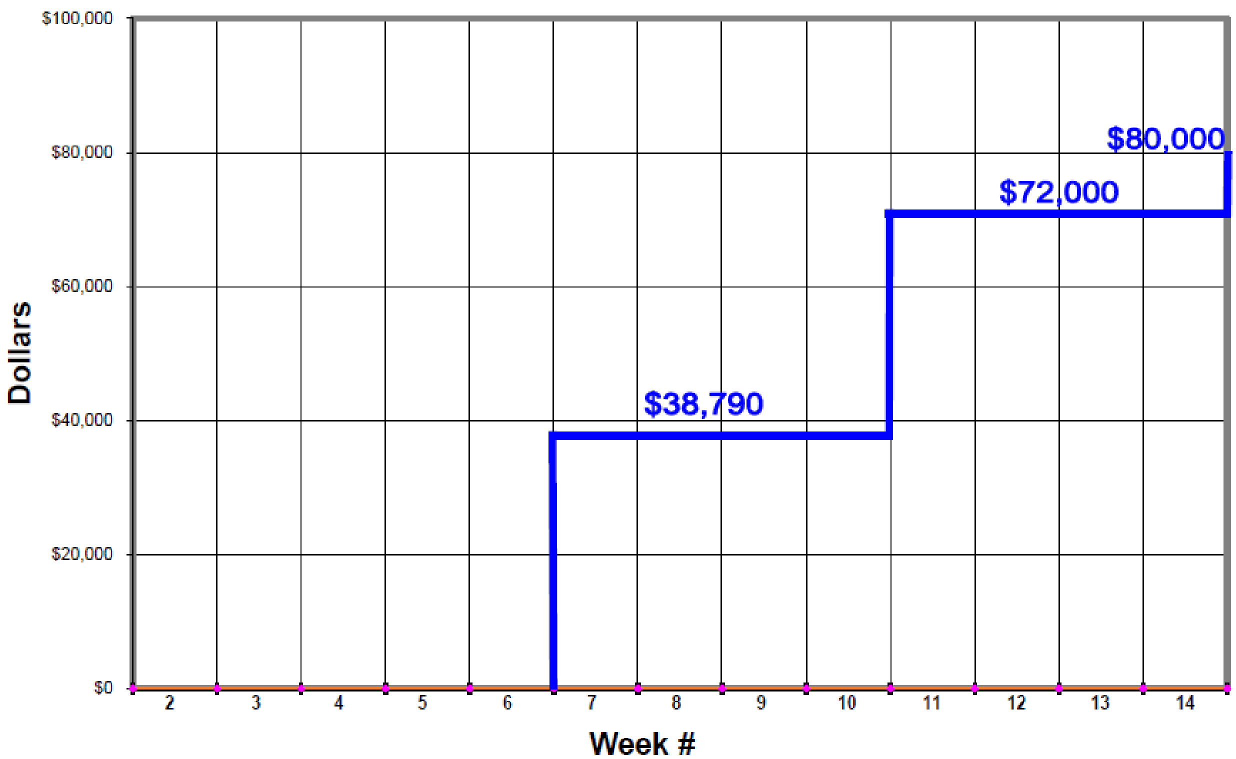

Figure 2-7 Cumulative Cash In Profile for the Plaza Project Example

Lag Between Making an Expenditure and Employee, Supplier, & Subcontractor Payments Cash Out

Generally, the prime contractor is not required to pay expenditures immediately. There is a lag between incurring a cost and making the payment to the employee, supplier, and subcontractor. In the construction industry there is a wide variation of practice regarding payments for goods and services. The following paragraphs describe some of the common practice for each type of transaction.

Labor

It is common practice for the prime contractor to pay employees one week after they perform the work. The prime contractor will list all hours worked by employee at the end of each week. The prime contractor will then perform the payroll calculations and pay each employee one week from the end of the work week. Since labor is a large cost item on the project, payroll is an important consideration in a cash flow analysis.

Materials and Equipment

According to the Uniform Commercial Code Section 2-310, payment is due for goods supplied at the time and place of delivery, unless the parties have agreed otherwise. (Fullerton & Knowles, 2017). Some suppliers do not extend credit and follow this doctrine requiring payment at the time of delivery. This method of payment is called cost on delivery (C.O.D.). With C.O.D. there is no lag between the delivery of materials and payment. However, most suppliers and prime contractors usually agree to alternate payment terms so there is a wide variation in the time period between purchasing and receiving materials and paying for them. Some suppliers, especially sole source suppliers, require materials to be prepaid before the supplier will fabricate and/or ship the materials. Prepayment for materials is common when the prime contractor does not qualify for credit.

Most construction materials are purchased on credit. The time lag between delivery (which begins the payment clock) and actual payment depends on the supplier’s terms and the prime contractor’s payment policy. Many suppliers offer a discount of one half, one, or even two percent of the invoice amount if materials are paid for within a set number of days from delivery. This discount period, if offered, is usually 10 to 15 days. For late payments suppliers will generally charge interest. Interest on the balance due typically begins 30 days after delivery. For cash flow projections, the forecaster uses the average number of days that elapses between delivery and the prime contractor’s payment for the materials. If the value of materials delivered is large and the payment lag is substantially different than the average, then the precise payment lag should be used.

The lag between use of rental equipment on the jobsite and payment is governed by the rental agreement. Construction equipment rental companies usually extend credit terms for qualified prime contractors.

Subcontractors

Small subcontracts are sometimes paid within a few weeks of the work being performed. This is especially true for highly specialized subcontractors, like concrete coring subcontractors that may have less than one day's work on the project. Subcontractors paid in this manner are treated similar to material suppliers for cash flow forecasting.

Larger subcontracts often include a paid-when-paid clause and will be subject to retainage. The paid-when-paid clause is also included on larger sub-subcontracts. Subcontracts with a paid-when-paid clause have a much greater payment lag than that of materials. Typically the prime contractor will pay the Subcontractor seven days after receipt of payment from the Owner

Cash Out Assumptions and Cash Out Table for the Plaza Project Example

The information in Figure 2-8 was generated by applying the following assumptions to the Plaza Project Example data. *A sample calculation is included with each assumption.*

- The material for Concrete Foundations & Sidewalks activity is delivered on the day needed. Assume that ¼ of the material is delivered each week of the four week activity. *¼ x $9,000 = $2,250 per week.*
- Prime contractor pays for material 3 weeks after delivery. *The prime contractor pays the supplier at the end of week #4 for material delivered in week #1.*
- Prime contractor pays equipment costs 3 weeks after they are invoiced. They are invoiced at the end of each week used. *The prime contractor pays the equipment rental company at the end of week #4 for equipment used in week #1.*
- Prime contractor pays labor costs, mobilization, and general condition costs one week after the work is performed. *The last payments totaling $500 are made at the end of week #7, one week after all work is completed on the project.*
- Prime contractor pays subcontractor one week after the prime contractor is paid for the work; "paid when paid." *Prime contractor receives progress payment #2 at the end of week #10, therefore the subcontractor is paid at the end of week #11.*
- Prime contractor retains 10% from subcontractor's payment. *The net progress payment to the subcontractor is $10,000 (100% of the work) less $1,000 (10%) = $9,000.*
- Retainage returned 1 week before prime receives retainage. *The assumption is that the prime contractor will receive the final payment for retainage at the end of week #14.*

Therefore, the prime contractor must make final payments to all subcontractors by the end of week #13.

- Prime contractor receives a waiver of all liens for the project & also an affidavit that all subcontractor payrolls & other bills connected with the subcontractor's work have been paid before making the final payment to the subcontractor. The “paid when paid” clause does not apply to the final subcontractor payment.
- An equal amount of work is done each week. Divide the estimated cost of labor, equipment, and general conditions by its duration to calculate the estimated cost per week. The duration of the general conditions is the project duration. *The labor cost for the site preparation labor is $8,000/2 weeks = $4,000 per week.*

Cash Out																
Activity	Estimated Cost	Week #1	Week #2	Week #3	Week #4	Week #5	Week #6	Week #7	Week #8	Week #9	Week #10	Week #11	Week #12	Week #13	Week #14	Check Totals
Mobilization	$1,000		$1,000													$1,000
Site preparation -- *labor*	$4,000		$2,000	$2,000												$4,000
Site preparation -- *equipment*	$8,000				$4,000	$4,000										$8,000
Concrete foundations & sidewalks -- *labor*	$9,000		$2,250	$2,250	$2,250	$2,250										$9,000
Concrete foundations & sidewalks -- *mat*	$9,000				$2,250	$2,250	$2,250	$2,250								$9,000
Plaza equipment -- *labor*	$8,000					$4,000	$4,000									$8,000
Plaza equipment -- *material*	$16,000					$16,000										$16,000
Seeding & landscaping -- *subcontract*	$10,000											$9,000		$1,000		$10,000
General conditions (project indirect costs)	$3,000		$500	$500	$500	$500	$500	$500								$3,000
Total Project Cost	$68,000	$0	$5,750	$4,750	$9,000	$29,000	$6,750	$2,750	$0	$0	$0	$9,000	$0	$1,000	$0	$68,000
Cumulative Cash Out		$0	$5,750	$10,500	$19,500	$48,500	$55,250	$58,000	$58,000	$58,000	$58,000	$67,000	$67,000	$68,000	$68,000	

Figure 2-8 Cash Paid Out by Prime Contractor for the Plaza Project Example

Cash Out Profile for the Plaza Project Example

The cash-out profile is a plot of cumulative dollars paid by the end of each week by the prime contractor as shown in Figure 2-8. Because checks are issued to many parties (employees, suppliers, equipment rental companies, and subcontractors) over the course of a week, this profile is plotted as a straight line from the cumulative cash-out at the end of one week to the cumulative cash-out of the subsequent week.

Figure 2-9 shows the cumulative cash in and cash out profiles for the plaza project example.

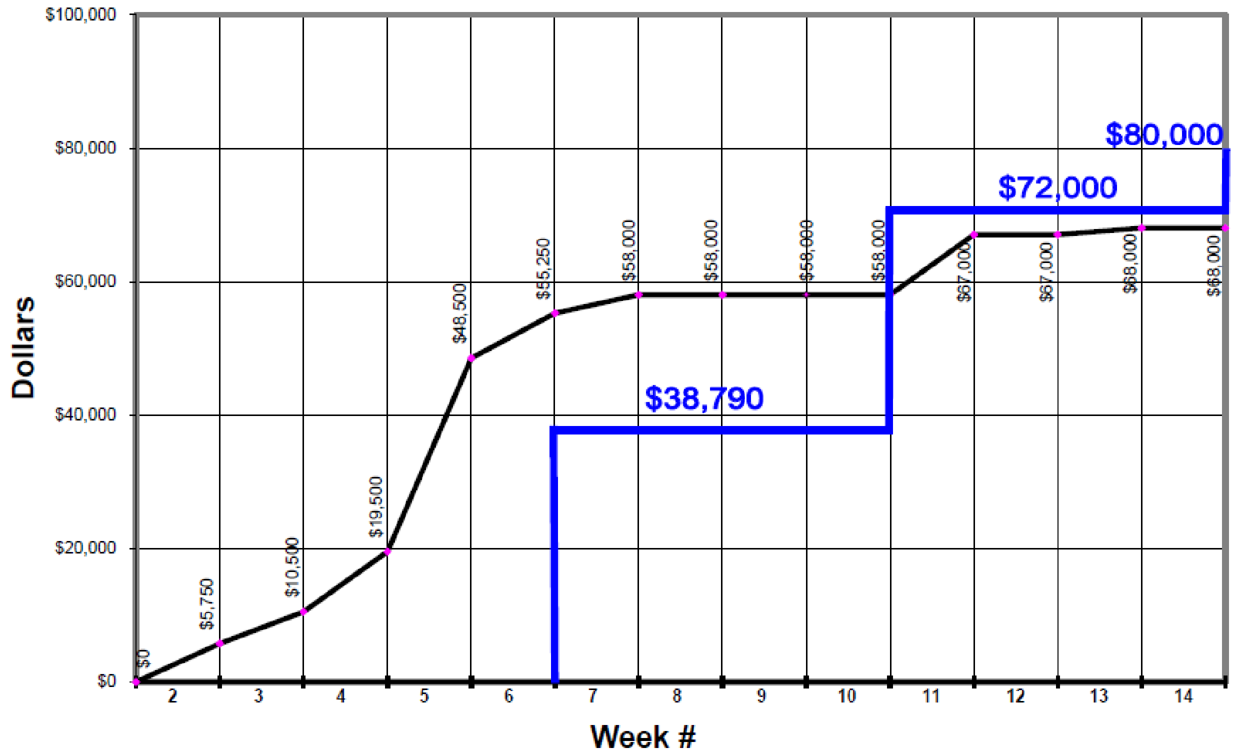

Figure 2-9 Cumulative Cash In and Cash Out Profiles for the Plaza Project Example

Project Overdraft

The project overdraft is the difference between the cumulative cash out (money paid by the prime contractor to employees, suppliers, equipment rental companies, and subcontractors) and the cumulative cash-in (money received by the prime contractor). The project overdraft profile plots the difference between the project cash-in and the project cash-out. In creating the profile it is assumed that the prime contractor makes all payments for the week before recognizing a payment received from the owner. See the plaza project example cash flow profile, Figure 2-10.

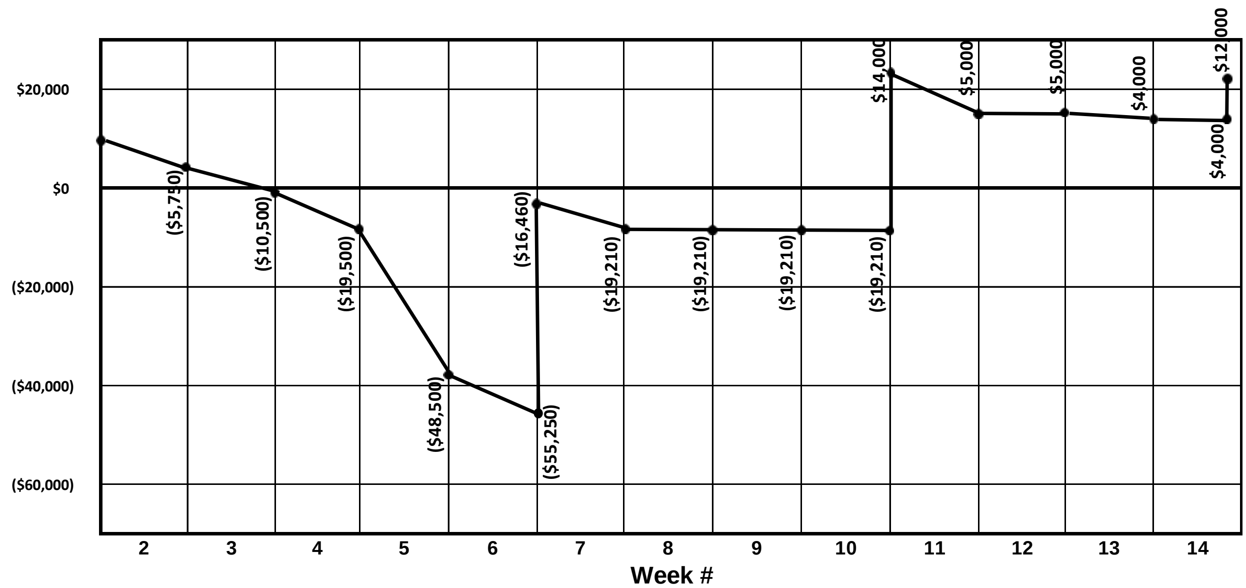

Figure 2-10 Project Overdraft Profile for the Example Project

Methods to Improve Project Cash Flow

Once the project manager understands project cash flow well enough to be able to forecast it; he or she will be able to make decisions to improve the project cash flow. Listed below are several strategies for improving cash flow.

- Work efficiently - a cost performance better than the budget will lower the cash out requirements and thereby decrease the project overdraft. Cost efficiency not only enhances the cash flow, but it also increases the total gross margin of the project since the cash in remains the same for a fixed price contract. See the calculations below for the impact of a 10% reduction in the costs budgeted for the project.

Gross Margin in the bid = $80,000 – $68,000 = $12,000

Reduce project cost by 10%, $68,000 – (10% x $68,000) = $61,200

Actual Gross Margin = $80,000 – $61,200 = $18,800

The increase in Gross Margin is $18,800/$12,000 = 1.5667 or 57% increase

- Submit pay applications on time - late submittals of pay applications are usually not accepted; this causes a one-month delay in being paid.
- Schedule major material deliveries at the end of pay periods - this will minimize the time between when the supplier is paid and the time the prime contractor receives payment for the work.

- Always pay subcontractors and suppliers on time according to the signed agreements. Here are some of the consequences of late payments.
    - Prime contractor will receive higher or no bids on future projects
    - Prime contractor will pay interest charges on late payments
    - Prime contractor will lose credit privileges
    - Prime contractor will lose preferred customer status
- Request a mobilization payment - the prime contractor can usually include a pay item for expenditures made by the prime contractor early in the project. These upfront costs include bonds, temporary utilities, and move-in costs.
- Negotiate lower retainage, shorter payment lag, and more frequent billings for all private work and public work contracts where these terms can be negotiated. One common practice is for the owner to stop withholding retainage once the project is 50-percent complete.
- Make repeated requests for late payments - be persistent in your efforts to receive your payment from an owner and the general prime contractor. Make your requests on the phone, in writing, and in person.
- Join forces with other creditors - joint action is more effective in getting the owner's attention.
- Check contract payment terms in the contract documents before submitting bids. Do not submit a bid or add contingency to the bid for unfavorable terms
- Exercise the stop work for late payment clauses in many contracts. Usually the notice to stop work is all that is required.
- File a lien - this will require legal counsel, but it will secure your money.

Summary

Project cash flow is the lifeline of the contractor. It is the project manager's responsibility to ensure the contractor is promptly paid. To carry out this responsibility, the project manager must know and follow all contract provisions regarding payment from the owner as well as the provisions for payments to subcontractors and suppliers.

There are many types of construction pricing methods, the most common are fixed price (lump sum), cost plus, and unit price. This chapter explained the fixed price contract payment procedure. Most fixed price contracts require a breakdown of the contract amount into the schedule of values before the first progress payment application is accepted. The prime contractor will require each subcontractor to submit a schedule of values for the subcontract scope of work which will be incorporated into the prime contractor's own schedule of values. For the chapter example a proportionate amount of the time dependent general condition costs and markup were added to the estimated total cost of each bid item to calculate the scheduled value for the item. Pay requests for the chapter plaza project were prepared using the approved schedule of values and the proposed time schedule to forecast the contractor's cash inflow. Typically, the owner retains part (often 10%) of each payment which is returned with the final payment.

Generally, the contractor's pay requests are submitted at the end of the pay period stipulated in the contract. Before issuing a payment certificate, the owner's agent reviews the application and usually visits the site to either verify the actual construction progress or request adjustments to the pay request. When satisfied that the pay request is accurate, the owner or their agent certifies the pay request for payment. The owner will then pay the contractor at the times stipulated in the contract, this creates a time lag between the contractor doing the work and being paid.

Owners will not make the final payment to the prime contractor until contract closeout requirements have been completed to the owner's satisfaction. Because construction lien laws give contractors and suppliers legal recourse if they are not paid for their services and materials, owners must ensure that all parties providing goods and services for the owner's project have been paid. Any unpaid party has the right to file a lien on the owner's property and the owner is required to pay these contractors and suppliers regardless of prior payments to the prime contractor for this work. To protect themselves from liens, owners require unconditional waiver of liens from all project contractors and suppliers before making the final payment.

Generally, contractors do not pay for their project expenditures immediately. The contractor's employees are typically paid the week after they perform the work. Most construction materials are purchased on credit. The time lag between delivery (which begins the payment clock) and actual payment depends on the supplier's terms and the prime contractor's payment policy. Rental agreements for construction usually include credit terms. It is common for subcontracts agreement to include paid-when-paid clauses. Also, subcontract payments are subject to retainage.

The project overdraft is the difference between the cumulative cash out (money paid by the contractor to employees, suppliers, equipment rental companies, and subcontractors) and the cumulative cash-in (money received from the owner). The project overdraft profile plots the difference between the project cash-in and the project cash-out. The chapter ended with several strategies for improving project cash flow.

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Chapter 3
Material Cost Control

Overview

Materials are those items that are assembled to create the finished project. The goal of material cost control is not only to minimize the total cost of materials, but also to increase labor productivity by providing the specified materials when and where they are needed. Construction materials are sold on either a lumps sum basis or a unit price basis. Custom fabricated materials are materials manufactured to meet specific requirements for items on the project. Custom fabricated items are typically sold to the contractor on a lump sum basis. Structural steel is an example of a custom fabricated material. The steel fabricator will do a detailed take-off from the project documents and then prepare and submit a lump sum bid including all required structural steel including connections for contractors bidding on the project. Most materials however are bulk commodities. Bulk commodities are construction materials that are interchangeable with nearly identical materials from other vendors. They are quoted and sold to the contractor on a unit price basis. The two components that determine the contractor's material costs are the quantity purchased and unit price. The unit prices are fixed by the purchase order and the total quantities purchased are determined by the project design plus any waste allowed by the contractor.

Material Cost (bulk commodities) = Quantity Purchased x Unit Price

The majority of the recommendations in this chapter apply to both custom fabricated and bulk commodity materials.

Learning Objectives

At the end of this chapter, the reader will be able to:

- Recognize and control all elements of material costs – quantities purchased and unit prices.
- Define the guidelines for minimizing the quantities purchased.
- Define the guidelines for obtaining the best prices.
- Define material expediting.
- Create and use the following documents/procedures to control all elements of material costs
    - Purchase orders
    - Expediting
    - Cost control reports

Quantity Control

If there was no waste on the project, the purchased quantity would be equal to the quantity required by the design documents. However, waste does occur and project management must work hard to minimize the amount of waste.

The following recommendations will assist project management in minimizing waste.

- Purchase correct quantities
- Order optimal material sizes
- Verify quantities ordered, received, and billed
- Verify quantities
- Verify quantities billed
- Protect materials on-site
- Eliminate rework

Purchase correct quantities

An accurate material take-off is required to purchase the correct quantities of material. The take-off required for the bid preparation is generally not sufficiently detailed for purchasing materials. A more detailed take-off is required. For example, the square feet of contact area is used to estimate the costs of job built concrete formwork. When ordering materials for this formwork, however, the purchase order must specify the exact type, dimensions, and quantities of Plyform, joists, studs, form ties, turnbuckles, scaffold brackets, guard rail posts, bolsters, chairs, and form release agents, and etc.

Costs associated with ordering too little material to complete the project include extra shipping charges and a lost quantity discounts. In addition, running out of material is a leading cause of lost labor productivity. Costs associated with ordering too many items include restocking charges, increased inventory shrinkage (stored materials are damaged or lost), and tying up cash in inventory. Also, the extra material will need to be unloaded and then reloaded increasing labor and equipment costs. Excess materials on site will need frequent relocation and will be subject to damage and theft.

One final note on purchasing the correct quantities, many contractors send excess materials to the company storage yard. Check the storage yard before buying materials for your project. It is inefficient to buy materials your company has already purchased and stored.

Order optimal material sizes

Another method of minimizing waste is to order the optimal size of each material for the specific needs of the project. The precut 2x4 stud is a good example of optimization in the procurement process. The precut stud is cut to 92 $^{5}/_{8}$" at the lumber mill so that cutting is not necessary on the jobsite. This stud length plus the thickness of the sole plate and two top plates forms the perfect height for an 8'- 0" ceiling. Not only is a precut stud less expensive than a 96" 2x4's, but there is a significant labor cost savings in not cutting each 96" 2x4. Chelsea Lumber Company of Chelsea, Michigan posted the following prices online, $2.98 for a 2x4x8 #2 SPF versus $2.87 for a 2x4x92-5/8" SPF precut stud (2017). This is a 3.7% savings. Learning about available sizes requires asking questions and studying the product literature. Think about optimal sizes in your field of construction. The final step in optimizing material sizes is to communicate the intended use of each size of material ordered to the work crews. Communicating this information can be as simple as making notes on a copy of the purchase order sent to the field. See Figure 3-1 for an example material list

Project: Westmoreland Armory
Client: Westmoreland College
Location: Kinloch, IN
PO 3918: Material List

Description	Quantity Each	Intended Use
SPF 2x4-92 ⅝"	34	Precut studs
SPF 2x4-16	44	Girts
SPF 2x4-18	6	Interior wall plates
SPF 2x6-92 ⅝"	100	Precut studs
SPF 2x6-16	22	Top plates & fascia
SPF 2x6-16 Treated	8	Sill plates
MSR 2x6-12	5	Headers

Figure 3-1 Material List for Carpenter Crew

Verify quantities ordered, received, and billed

Verification is required at each step of the procurement cycle to ensure the correct materials are ordered, received, and billed. The first step is to verify that the bid proposals meet the requirements of the plans specifications. This should occur on or before the project bid date. The bid proposals and a detailed take-off of the plans and specifications are used to prepare purchase orders. When the site office receives a copy of the purchase order the field staff should compare each purchase order to the project plans and specifications. It is better and less expensive to correct problems at this stage than after the material has been delivered. The next step is to verify that the material received on site is the same as the materials listed on the bill of lading (the list of materials shipped) before acknowledging receipt of the material. This verification requires a careful inspection for damages and a precise count of individual items. Suppliers will charge for everything the contractor has acknowledged receiving. The contractor's signature on the bill of lading is acknowledgement that everything on the list has been received. As soon as possible after delivery, the bill of lading should be compared to the purchase order to verify that the correct items were shipped and that there were no shortages (backorder) or overages in the quantity delivered.

Protect materials on-site

Protecting materials on-site is another requirement for minimizing waste. The contractor pays for all material that has to be reordered to replace material that was lost, stolen, or damaged on-site. The type of protection required on-site depends upon the type of material, the site layout, the geographic location of the project, and the seasonal weather. The type of protection required for primed structural steel at an existing rural facility is different than the protection required for new fire extinguishers at an urban building site.

Eliminate rework

A great deal of material is wasted each day because of rework. Rework generally requires new material to be purchased to replace the reworked material. As pointed out previously small material orders will cost more per unit because of shipping costs and lost quantity discounts. In addition rework requires demolishing part of the project, additional labor and equipment costs, and disposal costs for the demolished materials. Some materials like concrete cost much more to demolish than it did to install.

Unit Price Control
Lowest Bid from a Qualified Vendor

The goal of purchasing is to buy the correct quantities of the specified materials for delivery when and where they are needed at the lowest possible price. There are different methods of buying at the lowest price. One method is to solicit as many prices as possible in order to find the lowest price. A general contractor in Louisville, Kentucky solicits at least a dozen bids whenever possible. At one time this company found the lowest prices for hollow metal doors and frames delivered to their jobsite in Louisville were from a vendor in Cincinnati, Ohio, 103 miles away. The advantage of soliciting a large number of bids is that the contractor benefits from the competition in the marketplace. The disadvantage is that too often purchasing decisions are based on price alone. The differences between vendors regarding delivery, service, and quality are not fully evaluated. As described later in this chapter, the best value is not always the lowest price.

Another method of lowering the price paid for materials is to partner with a few good vendors. Vendors often reward repeat customers with discounts and/or preferred service. The advantages of this method to the contractor are discounts and/or preferred service. The disadvantage is that the contractor does not take full advantage of bargains in the marketplace.

Which method is better – solicit bids or partnering? The contractor can use both methods. Until a vendor has a track record of both competitive prices and outstanding service, the contractor is better served by soliciting multiple bids for each item. When contractors find outstanding vendors they can request an informal partnering agreement for discounts and/or preferred service in exchange for more purchases. This is a win – win situation for the contractor and the vendor. At any time either party can renegotiate the terms of the informal agreement. This way neither party is forced to retain an unfavorable business relationship.

When is the lowest price not the best value? The answer is when there are hidden costs, due to unsatisfactory quality and late delivery. The following list of questions should be answered during the evaluation of all material bids. Answers to these questions can add a substantial amount to the original quote.

- Is the scope of the bid clearly stated?
- Does the material meet the project plans and specifications?
- At what point does the buyer own the goods? See Figure 3-2

  F.O.B. means "Free on Board." Contracts, proposals or letters often state that materials will be delivered, for example, F.O.B. seller's plant, F.O.B. carrier or F.O.B. buyer's place of business. When the term is F.O.B. place of shipment (usually the seller's plant), the seller must put the goods into the possession of the carrier at that place. The seller bears the risk until the goods are in the possession of the carrier. It would be the seller's problem, for example, if the goods are stolen or damaged before the seller puts them in the possession of the carrier. If the term is F.O.B. vessel or carrier, the seller also bears the risk and expense of loading the goods for the carrier. If the term is F.O.B. the buyer's place of business or some other place of destination, the seller must deliver the goods to that place at the seller's risk and expense. (Fullerton & Knowles, 2017)

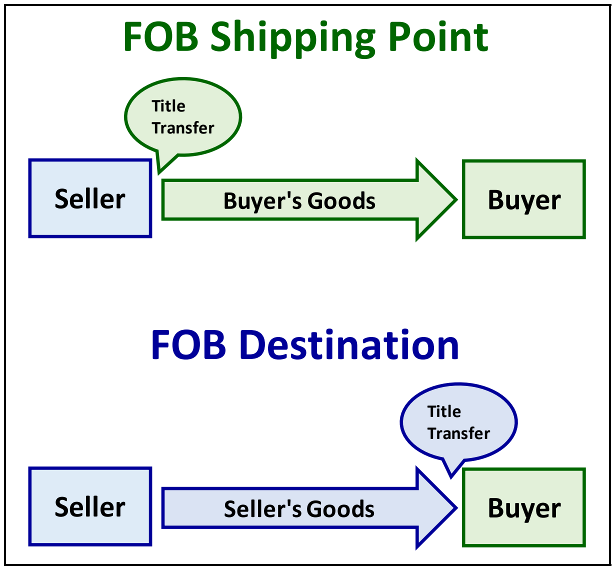

Figure 3-2 F.O.B. Definition

- Are freight costs to the project site included in the quote? The term C.I.F. means "the price includes in a lump sum the cost of the goods, the insurance, and the freight." The term C. & F. (or C.F.) means that the price includes "cost and freight" only (Fullerton & Knowles, 2017).
- Are all applicable sales taxes included in the bid?
- Will the promised delivery date support the project schedule?
- Does the vendor enjoy a good reputation with the contractor?
- Does the quote conform to the Uniform Commercial Code Article 2 on the Sale of Goods? Refer to http://www.fullertonlaw.com/uniform-commercial-code#m .

See Figure 3-3 for an analysis of quotes for hollow metal doors and frames.

Item Vendor -->	Arnold Inc.	B. Mitchell	Section 8 Inc.	The Ortoski Group	Rustybutts
Base Bid	$40,000	$36,000	$42,000	$43,500	$30,000
7% Sales tax if not included	$2,800	$2,520	$2,940	$0	$2,100
Add for welded frames if not included	$0	$0	$0	$0	$5,000
Add for shipping braces if not included	$0	$0	$0	$0	$2,000
Add for hardware preparation if not included	$0	$0	$0	$0	$0
Add for shop coat if not included	$0	$0	$4,200	$0	$3,000
Add for jobsite delivery if not included	$0	$5,000	$0	$0	$5,000
Add for glazed lites if not included	$0	$0	$1,200	$0	$1,200
Add for louvers in door type 'D' if not included	$0	$3,000	$0	$0	$3,000
Delivery time - 15 weeks required	14	14	17	12	18
Acceptable manufacturer?	Yes	Yes	Yes	Yes	No
Adjusted quote	$42,800	$46,520	$50,340	$43,500	$51,300

Figure 3-3 Bid Analysis – Section 081110 Metal Doors and Frames

Contracts for the Sale of Goods

After the quotes are evaluated, the contractor's bid is prepared, and the contractor is awarded the project contract, it is time to finalize contracts with each selected vendor. The goal of the written contract is to clearly communicate the agreement between the supplier and the contractor. The contract should have detailed descriptions of the material with references to plans, specifications, and applicable codes. The contract should list all required submittals, warranties, and samples. Specific shipping instructions including the hours deliveries are accepted at the project site are to be included in the contract. Another important part of the contract is the commercial terms – price, discounts, payment terms, escalation, and insurance. Chapter 4 – Uniform Commercial Code Sale of Goods of the Fullerton & Knowles Construction Law Survival Manual provides an excellent discussion on contracts for the sale of goods.

Go to http://www.fullertonlaw.com/construction-law-survival-manual for free access of the Construction Law Survival Manual. Also see Appendix 6, the sample supplier proposal, in the Construction Law Survival Manual.

Material Expediting

Late delivery of materials results in extra costs as work is delayed. In order to make-up this lost time the planned work sequences need to be altered and/or the work must be accelerated at additional cost. To ensure on time delivery the contractor must monitor the progress of each purchase order. This monitoring is known as material expediting. Custom fabricated materials progress though the following sequence.

- Submittal process that includes shop drawings, catalog information, samples, and/or erection drawings
- Fabrication
- Shop testing and inspections
- Shipping and receiving

To expedite is to cause something to be done or progress more quickly. (Cambridge) Constant monitoring of material orders alerts the contractor of any possible schedule slippages. This early warning allows the contractor to apply pressure on suppliers to take corrective action to reverse the slippage. This pressure may persuade fabricators to adjust their fabrication schedules to bring the ship date back to the agreed upon date. Attention is paid to those problems that are made most noticeable, “the squeaky wheel gets the grease.” (Cambridge) Even if the shipping date is not restored this early warning gives the contractor time to develop a work around schedule for the late materials. An expediter worksheet, see Figure 3-4, can be used to organize the expediting process. Most of the expediting can be done by email/telephone though shop visits are often needed. Some suppliers make status reports on their web page. Instructions for using the Expediter Worksheet, contact the supplier's representative on a regular basis, record the latest shipping date and enter it onto the worksheet. Look at the HM Door & Frames entry on Figure 3-4. There appears to be a problem here.

Project: Westmoreland Armory
Client: Westmoreland College
Location: Kinloch, IN

P.O. #	Item	Original Ship Date	Ship Date as of March 15	Ship Date as of March 31	Ship Date as of April 15	Ship Date as of April 30
3925	Wall Lockers	July 12	July 12	July 22	July 22	July 22
3926	Athletic Lockers	July 25	July 25	July 25	August 15	August 1
3927	Toilet Accessories	June 30	June 30	July 15	June 30	June 30
3928	Toilet Partitions	July 5	July 5	July 15	July 15	July 15
3929	Athletic floor surface	July 10	August 25	August 25	August 1	August 1
3930	HM Doors & Frames	May 1	May 1	May 1	May 1	September 9
3932	Door Hardware	July 1	July 1	July 1	July 15	July 15

Figure 3-4 Expediter Worksheet

An important aspect of expediting is contacting, the supplier's key person to confirm shipping dates, see Figure 3-5 example contact list.

Project: Westmoreland Armory
Client: Westmoreland College
Location: Kinloch, IN

P.O. #	Item	Company	Contact	Phone	FAX	e-mail
3925	Wall Lockers	The School Locker Company	Joan Reese	317-555-0105	317-555-0112	jreese@slc.none
3926	Athletic Lockers	The School Locker Company	Sam Dillon	317-555-0175	317-555-0117	sdillion@slc.none
3927	Toilet Accessories	Divisional Products, Inc.	Steve Varco	317-555-0162	317-555-0103	svarco@dpi.none
3928	Toilet Partitions	Divisional Products, Inc.	Steve Varco	317-555-0101	317-555-0165	svarco@dpi.none
3929	Athletic floor surface	Mouse Recreation Products	Rick Boggs	317-555-0110	317-555-0106	rboggs@mpi.none
3930	HM Doors & Frames	Rustybutts, Inc.	John Begovich	800-555-0164	800-555-0165	jbegovich@rbi.none
3932	Door Hardware	Chuck Isaly Supply	Dale Saylor	317-555-0125	317-555-0183	dsaylor@cis.none

Figure 3-5 Supplier Contact List

Material Cost Reports

The material cost report, see example, is the tool the contractor uses measure material cost performance. The report compares the material budget for each account or purchase order to the forecasted final cost. The forecasted final cost is the total dollar value of purchase orders written (committed dollars) plus the dollar value of all forecasted purchases. A variance analysis can be performed to determine how much of the difference between forecasted and budgeted costs are due to a difference in quantities and how much are due to a difference in unit costs. See Figure 3-6, Subcontract Cost Report

Project: Westmoreland Armory | Report #: 8
Client: Westmoreland College | Period Ending: 8/31/20XX
Location: Kinloch, IN

P.O. #	Vendor	Description	Budget at Completion	Paid To-date	Committed To-date	Estimate To Complete	Estimate at Completion	Variance at Completion
3925	The School Locker Company	Wall Lockers	$7,500	$6,500	$7,700	$0	$7,700	($200)
3926	The School Locker Company	Athletic Lockers	$8,750	$4,600	$9,250	$0	$9,250	($500)
	None issued	Toilet Accessories	$6,800	$0	$0	$6,800	$6,800	$0
3928	Divisional Products, Inc.	Toilet Partitions	$2,250	$0	$2,250	$0	$2,250	$0
3929	Mouse Recreation Products	Athletic floor surface	$4,800	$0	$4,800	$700	$5,500	($700)
		TOTALS	$30,100	$11,100	$24,000	$7,500	$31,500	($1,400)

Between the September 1 and the September 30 reports, the following took place.

>>> PO# 3926 was paid $4,400 in September

>>> PO # 3927 was issued for $6,800 to Divisional Products, Inc. in September.

>>> The Forecast To Go for PO# 3927 was decreased by an amount equal to the increase in Committed To-Date in September

>>> $500 was added to the Forecast To Go in September for PO# 3929 for changes to the floor graphics

Project: Westmoreland Armory | Report #: 9
Client: Westmoreland College | Period Ending: 9/30/20XX
Location: Kinloch, IN

P.O. #	Vendor	Description	Budget at Completion	Paid To-date	Committed To-date	Estimate To Complete	Estimate at Completion	Variance at Completion
3925	The School Locker Company	Wall Lockers	$7,500	$6,500	$7,700	$0	$7,700	($200)
3926	The School Locker Company	Athletic Lockers	$8,750	**$9,000**	$9,250	$0	$9,250	($500)
3927	**Divisional Products, Inc.**	Toilet Accessories	$6,800	$0	**$6,800**	**$0**	$6,800	$0
3928	Divisional Products, Inc.	Toilet Partitions	$2,250	$0	$2,250	$0	$2,250	$0
3929	Mouse Recreation Products	Athletic floor surface	$4,800	$0	$4,800	**$1,200**	$6,000	($1,200)
		TOTALS	$30,100	$15,500	$30,800	$1,200	$32,000	($1,900)

The transactions shown in bold represent the September changes.

Figure 3-6 Material Cost Report

Cost Report Terminology

Purchase Commitments - a firm obligation to acquire goods or services from a supplier. Companies enter into purchase commitments in order to lock in a particular price. https://www.accountingtools.com/search?q=commitment%20 accessed July 11, 2017

Commitment - a legal undertaking to commit capital at a future date such as the placement of a purchase order.

Payment - this is cash out

Commitment and payment definitions from http://www.nexuspmg.com/cost-management/understanding-commitments-expenditures-payments/ accessed July 11, 2017

Purchase orders - considered the best accounting practice for managing the ordering of goods and services - have been around for more than 100 years. They allow companies to specify, confirm and track every detail of an order placed with a vendor. In construction, purchase orders are even more valuable since they enable contractors to never lose sight of committed costs from the beginning to the end of a project. Efficient construction purchase order systems provide such advantages as:

- Guarding against overpaying or double-paying invoices
- Ordering flexibility to avoid project delays
- Verifying delivery of goods

https://www.foundationsoft.com/job-costs-purchase-orders/ accessed July 11, 2017

Budget at Completion - the dollar amount included in the original estimate plus approved change orders

Paid To-date - the dollar amount of invoices paid to-date

Committed To-date - the dollar amount of purchase orders issued to-date

Estimate To Complete - the predicted dollar amount of future purchase orders or changes to purchase orders

Estimate at Completion - the dollar amount of purchase orders issued to-date plus future purchase orders or changes to purchase orders

Variance at Completion - the Budget at Completion minus the Estimate at Completion

Causes of Cost Variances in Materials Management

The following are frequently cited causes for cost variances in construction materials management. This list is adapted from a conference paper (Veronika, Riantini, & Trigunarsyah, 2006)

- Restocking fees
- Materials damaged on site
- Loss of materials
- Late delivery of materials (impacts schedule)
- Unreported material damage at delivery
- Relocating materials
- Incorrect material take-off
- Changes of materials quantity required
- Jobsite theft
- Uneconomic order quantity
- Material waste (over usage)
- Purchasing the wrong materials
- Excess site storage cost

Summary

The two components that determine the contractor’s material costs are the quantity purchased and unit price. The unit prices are fixed by the purchase order and the total quantities purchased are determined by the project design plus any waste allowed by the contractor. This chapter included several recommendations to help project management minimize waste and limit the quantity purchased. Also discussed were strategies for obtaining the lowest material prices from qualified vendors through competitive bidding and/or partnering agreements. Ideas for effective evaluation of price quotes were presented.

Higher material costs also occur through miscommunication in the purchase agreements. Contracts for the sale of goods clearly communicate and document the agreement. One aspect of material cost control frequently missing is material expediting. Material expediting includes all of the steps in the supply chain from purchase agreement to delivery on site.

The chapter concluded material cost report, the tool the contractor uses measure material cost performance. Material cost report terminology was explained. Included in this discussion was a list of frequently cited causes for material cost variances.

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Fullerton & Knowles, Construction Law Survival Manual, Chapter 4 - Uniform Commercial Code Sale Of Goods, http://www.fullertonlaw.com/index.php accessed June 27, 2017

Veronika, Riantini, & Trigunarsyah, 2006, Corrective Action Recommendation for Project Cost Variance in Construction Material Management, Proceedings of the tenth East Asia-Pacific Conference on Structural Engineering and Construction : (EASEC - 10), August 3-5, 2006, Bangkok, Thailand.

Chapter 4
Subcontract Cost Control

Overview

Building construction is subcontractor intensive due to the number of specialty contractors needed. Items typically subcontracted include excavation, masonry, steel erection, glazing, interior finishes, mechanical, and electrical.

This chapter presents the guidelines for the cost control of subcontractors with examples from actual projects to illustrate the guidelines. The purposes of the guidelines are to solicit low bids from qualified subcontractors and to limit subsequent claims or growth in the contract amount.

Good subcontract cost control, like all human endeavors, is simply good communication. According to Webster's New Collegiate Dictionary, communication is "a process by which information is exchanged between individuals through a common system of symbols, signs, or behavior." Virtually all problems in subcontract cost control are caused by poor communications. The guidelines listed below will, when followed, produce an effectively managed project. The purpose of each guideline is to improve the communications between the prime contractor and its subcontractors. Each guideline will be discussed in detail in subsequent sections.

- Clearly define the subcontract scope.
- Actively solicit bids.
- Analyze all aspects of each bid.
- Document the subcontract agreement.
- Hold pre-job meetings.
- Hold weekly subcontractor coordination meetings.
- Identify the key contact people.
- Inspect all subcontract work.
- Analyze subcontract cost performance.

Chapter Objectives

At the end of this chapter, the reader will be able to:

- Recognize and control the components of subcontract costs – bids, changes, administration, and interference.
- Define the guidelines for managing subcontract costs.

- Analyze subcontractor cost performance.

Subcontract Scope

The subcontract scope definition is the most important provision in the subcontract agreement. Most subcontract problems are caused by inadequate subcontract scope definitions. Scope definition problems begin with the evaluation of subcontractor bids. Often the scope definition included with the subcontractor bid is cursory and lacking detail. In addition the prime contractor's staff evaluating the bid often have a shallow understanding of the subcontractor's specialty and/or the project requirements. The result is that there are frequently gaps or overlap between the various subcontracts. These gaps become all too apparent during the construction process and costly disputes arise.

An additional problem is that the subcontract scope definitions often rely on the individual specification sections of the project documents that are developed by the project designers (see Figure 4-1, Example Subcontractor Scope and Bid). At least some designers are aware of this practice of using the specification section descriptions for subcontract scope definition and have discouraged it by adding disclaimers to the specifications such as the American Institute of Architects (AIA) Document A201, General Conditions of the Contract for Construction Article 1.2.2 which states, "Organization of the specifications into divisions, sections, and articles, and arrangement of Drawings shall not control the Contractor in dividing the Work among Subcontractors or in establishing the extent of Work to be performed by any trade."

Pythagorean Casework, Inc. July 12, 20XX

Project: North Lafayette Elementary School, Lafayette, IN

Our scope of work includes: Specification Sections
12 35 50 Manufactured Educational/Library Casework
12 36 23 Plastic-Laminate-Clad Countertops

SPECIFIC ITEMS INCLUDED
Cabinet hardware
Cabinet locks as shown
Installation

Quote, Fabricated & installed **$31,500.00**

ADDENDA #1 and #2 included in this bid.

Figure 4-1 Example Subcontractor Scope and Bid

The purpose of the design process is to provide the owner with a facility in which the owner can pursue the owner's goals and not necessarily to provide subcontract scope documents. The designer interfaces with the owner to determine the overall scope of a project and to communicate the scope to the construction team. The designer does this by producing drawings and specifications. According the American Institute of Architects (AIA) Document A201, General Conditions of the Contract for Construction Article 1.1.6 specifications are that portion of the Contract Documents consisting of the written requirements for materials, equipment, systems, standards and workmanship for the Work, and performance of related services. There is nothing here about subcontract scope definition. Construction specifications vary substantially from project to project and from designer to designer. Frequently, work is specified in more than one specification section. Sometimes, the different specification sections contradict each other.

On one project, the specifications conflicted regarding the millwork finish. *Division 6 – Wood, Plastics, and Composites* required all millwork to be sealed and varnished at the fabrication shop. However, *Division 9 - Finishes* required all millwork to have one field coat of stain and two field coats of polyurethane. This discrepancy was particularly troubling because it affected the scope of two separate subcontractors and was not addressed during the negotiations of the effected subcontracts. The prime contractor assigned the work to the painting subcontractor. The painting subcontractor filed a claim to be paid extra for this finishing. This claim led to an expensive lawsuit.

How can good subcontract scopes be written? The best solution is for the prime contractor and the subcontractor to review a scope definition and price before bid day, but in order to keep a competitive edge and to avoid bid shopping, subcontractors rarely submit a price earlier than a few hours (or even minutes) before the bid is due to the owner. The detailed scope definition for a bid package should be developed by one party and sent to the other party for review and comment. By bid day, both parties should agree on the scope. The advantage for the prime contractor to prepare the detailed scope definition for comment is that all subcontractors bidding that phase of the project should be submitting bids for the same scope definition.

However, there are advantages for the subcontractor to prepare the scope definition. One advantage is the subcontractor has a better understanding the construction specialty and is in a better position to develop the scope. Another advantage to the subcontractor is that it is more efficient to prepare bids for one scope definition per project instead of preparing a custom bid for the scope definition of each prime contractor. Regardless of who prepares the subcontract scope it is in the best interest of both the prime bidder and subcontract bidders to have the same understanding of the scope definition for the subcontract.

It is essential that both the prime contractors and subcontractors thoroughly understand the plans and specifications including the discrepancies, omissions, and conflicting documents. It is easier for the prime bidders and the subcontract bidders to communicate the subcontract scope to each other when they thoroughly understand the specifications and drawings.

Bid Solicitation

The prime contractor must actively solicit bids. It is good business for the prime contractor to ensure they receive all subcontractor bids for the project. Likewise, subcontractors must track leads and opportunities to bid. Active participation in trade and owner associations provides access to construction business information. Below are some methods of assuring that a prime contractor receives all subcontract bids.

1. Be listed as a plan holder by the owner and designer.
2. Be listed by all of the plan rooms, builder exchanges and construction information services in your area such as FW Dodge and ConstructConnect
3. Send bid requests subcontractors. It is common for the best bid to be received through a bid solicitation. Construction bid software is available to manage this task.

Subcontractor Bid Shopping

No discussion of subcontractor bid solicitation is complete without commenting on bid shopping.

The following statement is part of the "Guidelines for a Successful Construction Project" which was jointly developed and produced by three leading construction trade associations - the Associated General Contractors of America (AGC), the American Subcontractors Association, Inc. (ASA) and the Associated Specialty Contractors (ASC). (Guidelines, 2003)

> B.4 - Guideline on Bid Shopping and Bid Peddling
>
> Bid shopping and bid peddling are abhorrent (objectionable) business practices that threaten the integrity of the competitive bidding system that serves the construction industry and the economy so well. The bid amount of one competitor should not be divulged to another before the award of the subcontract or order, nor should it be used by the contractor to secure a lower proposal from another bidder on that project (bid shopping). Neither should the subcontractor or supplier request information from the contractor regarding any sub bid in order to submit a lower proposal on that project (bid peddling).An

important, but often unrecognized, business asset of the construction contractor is its proprietary information.

Proprietary information includes the price, the design or novel technique, or an innovative approach used in preparing a proposal. The preparation of bids, proposals, submissions or design-build documents is the result of professional consideration which is the intellectual property of the preparer, and so any such information should be considered proprietary. It is unethical to disclose to others, any information that is provided with an expectation that such information will be kept confidential.

Pre-bid Meetings

Attending pre-bid meetings helps both to clarify project scope and documents as well as identifying interested prime contractors and subcontractors. The pre-bid meeting minutes are frequently issued in an addendum and usually include the attendance list.

Bid Analysis

There are both direct and indirect subcontract costs. Direct subcontract costs are the amounts of money paid to the subcontractor for the original subcontract scope as well as for scope gaps, mandatory overtime premiums, reimbursement for repairs made to completed work, and etc. Direct subcontract costs are easy to analyze from the subcontractor bid. Indirect subcontract costs are the additional costs prime contractor incur because of subcontracts. Indirect subcontract costs are difficult to predict because they vary depending on which subcontractors are on the project. Indirect subcontract costs include:

- Delay costs caused by poor subcontract schedule performance.
- Loss of productivity to the prime contractor's labor caused by the subcontractor impeding the prime contractor’s craft employees.
- Extra costs for cleaning up after a subcontractor.
- Repair of work damaged by subcontractors.
- Excessive time spent by the prime contractor's supervision staff on problem subcontractors, to the detriment of other work.

If the indirect costs are substantial, identifiable to a specific subcontractor, and properly documented, they may be backcharged to the subcontractor. However, many times the cause of these indirect costs are not identifiable and therefore borne by the prime contractor. A proper bid analysis must include both the direct and indirect subcontract costs. Indirect costs are difficult to quantify and are therefore frequently ignored in the competitive bid environment. The following factors should be considered for each subcontractor during the bid analysis: price, technical qualifications, financial ability, safety, labor relations history, and the ability to meet the schedule.

Subcontract price

The ideal subcontract bid price is low, but not too low. A very low bid likely indicates that the scope is not complete or there is an error in the bid. While subcontractors can usually be legally liable for their bid price (search "Drennan Rule" on the internet), the cost of litigation is often too expensive to pursue and therefore subcontractors have revoked their bids. (Note a prime contractor cannot legally accept an unconscionably low bid, search "Snap-up doctrine contracts" on the internet.) Also, a subcontractor who is losing money on the project will probably have below average performance. The dilemma in not using a suspiciously low subcontract bid is that one or more of the prime bidder's competitors will likely use that low bid.

The best strategy is to call the subcontractor with the low bid to discuss the scope definition and to suggest that all of the math be carefully checked. However, care must be used to avoid giving information about other subcontract bids.

Technical qualifications

One way to measure the technical qualifications of a subcontractor is to learn how many similar project of this type or size the subcontractor has done before. To help evaluate the technical qualifications of subcontractors submitting bids the prime contractor should keep a historical file of all subcontractors previously used. Included in this file should be evaluations by the prime contractor's project staff. In addition the prime contractor can request a list of similar projects with references from the subcontractor. Evaluating the resumes of the proposed key project personnel, whom the subcontractor plans to use, is another way to judge the technical qualifications.

Financial Ability, Labor Relations Ability to Meet Schedules and Safety Record

Financial ability is more volatile than are the technical qualifications. A subcontractor can be financially sound today, but be out of business within the year.

The evaluation of a subcontractor's labor relations and ability to meet schedules is also available from the historical files of past projects. Checking with the subcontractor's list of references can also elicit this information. The evaluation of the subcontractor's safety performance can be measured using the statistics of OSHA Form 100 and the experience modification factor for the subcontractor's workmen compensation insurance.

Try to think of the most unqualified subcontractor with whom you have had the misfortune to deal. Did the indirect costs associated with the subcontractor outweigh the subcontractor's price advantage by the end of the project? On one project, the masonry subcontractor delayed the project, did very little cleanup, damaged their own work and the work of others, did not pay vendors on time, blocked access around the site, and sued the prime contractor for alleged extra work. The prime contractor settled with this subcontractor for a minimal amount to avoid litigation costs.

Subcontract Agreement

The Subcontract Agreement is a legally enforceable document. It spells out precisely what each party has agreed to. An exact scope definition is critical for a good subcontract. The subcontract agreement should be a standard form. Some of the standard terms to be included in the contract are: the rights of each party, payment terms, remedies for non-performance or non-payment, and flow-through clauses. A flow-through clause binds the subcontractor to the provisions of the prime contract.

Subcontract agreements can be drafted by the prime contractor or the subcontractor, or negotiated by the two. It is generally recommended to use an industry standard subcontract agreement such as the AIA Document A401, Standard Form of Agreement between Contractor and Subcontractor. It is incumbent to verify the authority of each person who signs the subcontract. A contractor may add a clause to a contract that states the person signing is authorized to sign. Here is an example of such a clause. (Contract Signing Authority, 2013)

"The individual signing below hereby represents and warrants that s/he is duly authorized to execute and deliver this Agreement on behalf of Other Party and that this Agreement is binding upon Other Party in accordance with its terms."

Pre-Job Meetings

The prime contractor must be in constant communication with each subcontractor during the development of the overall construction plan. The subcontractors' needs regarding long lead-time items, site storage requirements, and the summary plan for the construction of each subcontractor's scope must be incorporated into the prime contractor's construction plan. Without the subcontractor's input, there will be no subcontractor commitment. Note, for items with long times, it is desirable to request an unpriced copy of the subcontractor's purchase orders. The submission of these copies should be a provision of the subcontract agreement. These planning discussions can be by phone or by holding meetings.

A separate pre-job meeting with each subcontractor must be held on-site. This meeting should be held about two weeks before the subcontractor moves onto the site. Both the prime contractor's and subcontractor's project managers and on-site supervisors must attend this meeting. At the meeting, there will be a detailed discussion of the schedule, assignment of site storage areas, job site rules, and all other matters relating to the subcontractor's performance on-site.

The pre-job meetings need to be run efficiently to be effective. The following are guidelines for conducting meetings:

- Send out meeting notices one week before the meeting.
- Include the agenda with the meeting notice.
- Start the meeting on time.
- The chairperson runs the meeting and keeps the discussion focused on one agenda item at a time.
- End the meeting on time.
- Send out the meeting minutes no later than the day after the meeting.
- Distribute corrections to the minutes to everyone receiving the minutes.

Weekly Coordination Meetings

Every week, the prime contractor's on-site supervisor must hold a regularly scheduled meeting with the on-site supervisors of each contractor who will be on-site during the next two weeks. The meeting should focus on the schedule, but other topics can be included. Each subcontractor is to submit his or her proposed two-week schedule to the prime contractor before the day of the meeting.

One agenda item is a review of each subcontractor's schedule for the next two weeks. By having all of the supervisors in one place, potential interference can be eliminated before they occur. The prime contractors must assure that each subcontractor's two-week schedule conforms to the overall project schedule.

A second agenda item is a list of critical action items. The Critical Items Action Report lists those problems that could potentially cause a significant schedule or cost variance. An item remains on the current list until it is completely resolved. Once the item is resolved, it is removed from the list. Each item listed must include the following:

- A description of the problem
- The potential impact of the problem
- The action(s) taken or to be taken to resolve the problem
- The date each action was completed or is to be completed
- The name of the subcontractor responsible for the action

Other agenda items include safety, clean up, and announcements. The minutes of the meeting include the revised two-week schedule, which was agreed upon at the meeting. This two-week schedule is issued by the prime contractor and includes the work of all subcontractors.

Key Contact People

An important concept of effective communications is to address the message to the correct audience. This is why it is important to have a list of the key contact people. Ideally, all communications should be between one person for the prime contractor, and one person for the subcontractor. However, it is frequently expeditious to communicate directly with one member of the project team. When this occurs, the communication needs to be documented and sent to each of the designated key persons for the prime contractor and for the subcontractor. Avoiding undocumented verbal instructions is a must.

Inspect All Subcontract Work

The prime contractor is responsible to the owner for the execution of the work per the contract documents. Allowing the subcontractor to produce non-conforming work puts the prime contractor in the position of forcing the subcontractor to correct the work, or puts the prime contractor in the position of correcting the work and then trying to collect from the subcontractor. Neither case is desirable; it is better to continually inspect the subcontractor's work, and to require a change in the process as soon as poor quality work is observed.

Subcontract Cost Report

The Subcontract Cost Report shows the total dollars spent and committed to-date, the predicted cost of the remaining work, and the projected overrun or underrun for each subcontractor. The objective of the Subcontract Cost Report is to identify subcontracts that are likely to exceed the budget. The sooner those cost overruns are discovered, the more effective corrective actions can be. See Figure 4-2, Subcontract Cost Report

Project: Westmoreland Armory							Report #:	8
Client: Westmoreland College							Period Ending:	8/31/20XX
Location: Kinloch, IN								
P.O. #	**Vendor**	**Description**	Budget at Completion	Paid To-date	Committed To-date	Estimate To Complete	Estimate at Completion	Variance at Completion
SC001	Caldwell Tank	Fabricate/Erect Tanks	$550,000	$280,000	$625,000	$0	$625,000	($75,000)
SC002	Cave Construction Co.	Civil Work	$2,800,000	$1,380,000	$2,500,000	$400,000	$2,900,000	($100,000)
SC003	Reddy Kilowatt Electric	Above Ground Electrical	$1,450,000	$120,000	$1,200,000	$250,000	$1,450,000	$0
SC004	Automaton, Inc.	Mechanical Work	$4,400,000	$1,800,000	$4,500,000	$0	$4,500,000	($100,000)
		T O T A L S	$9,200,000	$3,580,000	$8,825,000	$650,000	$9,475,000	($275,000)

Between the September 1 and the September 30 reports, the following took place.

The subcontractors were paid the following amounts.

- SC001 - $150,000
- SC002 - $400,000
- SC003 - $200,000
- SC004 - $900,000

The amount of subcontract SC002 was increased by $400,000. Estimate To Complete was reduced by a like amount).

The amount of subcontract SC003 was increased by $250,000. (Estimate To Complete was reduced by a like amount).

The Estimate To Complete for SC001 was increased by $60,000.

The Estimate To Complete for SC004 was increased by $40,000.

Project: Westmoreland Armory							Report #:	9
Client: Westmoreland College							Period Ending:	9/30/20XX
Location: Kinloch, IN								
P.O. #	**Vendor**	**Description**	Budget at Completion	Paid To-date	Committed To-date	Estimate To Complete	Estimate at Completion	Variance at Completion
SC001	Caldwell Tank	Fabricate/Erect Tanks	$550,000	**$430,000**	$625,000	**$60,000**	$685,000	**($135,000)**
SC002	Cave Construction Co.	Civil Work	$2,800,000	**$1,780,000**	**$2,900,000**	**$0**	$2,900,000	**($100,000)**
SC003	Reddy Kilowatt Electric	Above Ground Electrical	$1,450,000	**$320,000**	**$1,450,000**	**$0**	$1,450,000	$0
SC004	Automaton, Inc.	Mechanical Work	$4,400,000	**$2,700,000**	$4,500,000	**$40,000**	**$4,540,000**	($140,000)
		T O T A L S	$9,200,000	$5,230,000	$9,475,000	$100,000	$9,575,000	($375,000)

The transactions shown in bold represent the September changes.

Figure 4-2 Subcontract Cost Report

Summary

This chapter presented guidelines for the control of subcontractor costs. One of the most important subcontract cost control action is to write complete work scopes. The goal is ensure that the subcontract scopes are all-inclusive and minimize differing interpretations of the scope. All too frequently there are gaps or overlap between the various subcontract scopes. To correct scope gaps subcontracts must be amended to add the excluded work. These additions to the scope are often priced higher than they would have been if the work was included in the original scope. Conversely, deletions to the subcontract scopes do not yield the full value of the work. The best advice for writing complete subcontract scopes is for the prime contractor and the subcontractor to start early to review and negotiate scope definition beforehand and not wait until bid day when everything is hectic.

Another method for controlling subcontract costs is for the contractor to actively solicit bids. One way to accomplish this is notifying potential subcontractors of the contractor's intention to prepare a project bid. Also, the contractor must make certain they are listed on all project bidder lists.

Once bids are received they must be analyzed considering both direct and indirect subcontract costs. The direct subcontract cost is the subcontract amount. Indirect subcontract costs are all of the cost impacts on the contractor's project costs. Many of these indirect impact costs can never be recovered. The potential amount of indirect subcontract costs can be substantial but is difficult to analyze because these costs are so dependent on individual subcontractors and the effectiveness of the contractor's project management team. Specific items to include in the subcontract bid analysis are price, technical qualifications, financial ability, labor relations record, the ability to meet schedules, and the subcontractor safety record.

The next step in controlling subcontract costs is to craft the subcontract agreement. The use of a standard contract form will help ensure that all pertinent aspects of the agreement are included.

Face-to-face meetings facilitate subcontract cost control. Pre-bid meetings between the owner/designers and potential bidders help to both clarify the project scope and to identify potential subcontractor bidders. Pre-bid meetings between prime contractors and subcontractors help assure complete subcontractor scopes of work. Pre-job meetings immediately following the contract award fosters the constant communication with each subcontractor required for development of the overall construction plan. A separate on-site pre-job meeting with each subcontractor in the weeks preceding the subcontractor's mobilization identifies potential problems before they occur. Finally, weekly on-site coordination meetings between the contractor and all subcontractors lead to an efficient project and benefits the contractor and all subcontractors.

References

Guidelines for a Successful Construction Project, (2003) https://www.discountpdh.com/course/guideline-on-general-contractor-subcontractor-relations.pdf accessed July 29, 2017

Contract Signing Authority, (2013) https://www.proformative.com/questions/contract-signing-authority accessed May 15, 2018.

Chapter 5
Labor Cost Control

Overview

Construction labor cost is the most variable element of the project construction budget. Therefore, labor cost control is paramount to profitability for all contractors. Owners also have an interest in controlling labor costs for work performed in-house, and for work performed by contractors on a reimbursable basis. In order to control costs, project management must first develop a realistic budget to measure actual labor cost performance. A yardstick that is not exactly 36 inches long is of little use for measuring lengths. An inaccurate budget is similarly useless for measuring labor cost performance. In order to maintain budget control, project management must continually compare the actual dollars and workhours to the budget dollars and workhours to identify deviations. Once deviations are identified, project management must take swift corrective action to minimize cost overruns. Creating realistic budgets and sticking to them requires choosing an efficient cost control system for controlling construction labor costs.

The discussions in this chapter are illustrated using data from the concrete accounts of a warehouse project. See Figure 5-1 for the concrete labor budget for this example. Also review the section on control systems in Chapter 1. Good construction labor cost control methods utilize the feedback and corrective action elements of the control cycle discussed there. Note that while chapters 3 and 4 included advice on controlling material and subcontract costs, Chapter 5 concentrates on the process of controlling labor costs rather than providing specific advice.

Chapter Objectives

At the end of this chapter, the reader will be able to:

- Calculate installed quantities for construction activities using *rules of credit*.
- Collect actual labor workhours by cost account.
- Evaluate labor cost performance using earned value.
    - Calculate earned value
    - Calculate value of work scheduled
    - Calculate cost performance index and the cost variance
    - Forecast the estimate at completion

Account Number	Description	Quantity	Unit of Measure	Labor $/unit	Labor $
Spread Footings					
031 11 3455	Formwork	1,410	SF	$4.00	$5,640
032 10 6005	Place rebar	2.80	Ton	$650.00	$1,820
032 30 1756	Set Anchor Bolts	160	Ea	$10.00	$1,600
033 10 5724	Place concrete	72.0	CY	$30.00	$2,160
Dock Wall Footings					
031 11 3450	Formwork	270	SF	$4.00	$1,080
032 10 6010	Place rebar	1.00	Ton	$650.00	$650
033 10 5719	Place concrete	20.0	CY	$30.00	$600
Dock Walls					
031 11 4630	Formwork	1,500	SF	$2.50	$3,750
032 10 7020	Place rebar	0.80	Ton	$650.00	$520
033 10 6200	Place concrete	42.0	CY	$50.00	$2,100
033 52 9600	Rub walls with grout, front only	750	SF	$3.00	$2,250
	Total Concrete Labor Budget				$22,170

Figure 5-1 Concrete labor budget

Forecast Quantity

The first step in controlling costs is developing an accurate budget. The labor budget is based upon the original estimate. The estimated quantities become the budgeted quantities. Budget quantities are fixed for the entire project unless there is a change in the scope of the contract. Actual performance is measured by comparing the actual costs to the budgeted costs for the same scope of work.

We are all aware that sometimes the original estimate is based upon an inaccurate quantity take off. This creates a problem in measuring progress and realistically forecasting the cost of the project. For an account with an inaccurate budget quantity the actual percent complete is not equal to $\frac{\text{actual quantity}}{\text{budget quantity}}$ but it is equal to $\frac{\text{actual quantity}}{\text{forecast quantity}}$. Likewise, for an account with an inaccurate budget quantity the to go quantity is not equal to (forecast quantity – actual quantity), but it is equal to (forecast quantity – actual quantity.)

The forecast quantity is the most up to date and accurate prediction of the total scope of work. It incorporates all of the quantity information to date. The forecast quantity is equal to the budget quantity +/- any adjustments discovered during the construction phase. These adjustments may be due to estimating take-off errors, mistakes on the project, or any number of causes except for scope changes that are due to change orders from the owner. For scope changes due to change orders the budget is revised to reflect the new project scope.

After the fixed sum prime contract was signed the prime contractor recognized that the estimator made an error in taking off the length of the dock wall for a warehouse building. The prime contractor is responsible for completing this additional work at no additional cost to the owner. The estimator used a length of 135’ for the dock wall. The correct length is 162'. See Figure 5-2 for the forecasted quantities for the dock wall footing and the dock wall accounts.

Account Number	Description	Unit of Measure	Budget Quantity	Adjustment	Forecast Quantity
Dock Wall Footings					
031 11 3450	Formwork	SF	270	54	324
032 10 6010	Place rebar	Ton	1.00	0.20	1.20
033 10 5719	Place concrete	CY	20.0	4.0	24.0
Dock Walls					0
031 11 4630	Formwork	SF	1,500	300	1,800
032 10 7020	Place rebar	Ton	0.80	0.16	0.96
033 10 6200	Place concrete	CY	42.0	8.4	50.4
033 52 9600	Rub walls with grout	SF	750	150	900

Figure 5-2 Concrete Forecast Quantities

Measuring Labor Input

Labor is one of the resources that the contractor supplies to complete the work in each cost account. It is measured by the number of workhours expended on each individual cost account. The workhours are multiplied by the corresponding wage rates (i.e., dollars per workhour) to calculate the labor dollars expended by account. The bare labor wage rate is the gross direct wages paid to the worker. In addition to the bare wage rate the employer must also pay the labor burden. The labor burden includes the fringe benefits plus taxes and insurances that the employer pays based on labor payroll. The gross direct wages paid to the worker plus the labor burden equals the burdened labor. Because state taxes and workers compensation insurance rates vary by state, the labor burden varies by state. See Figure 1-10 for an example of typical items included in the labor burden. See the time cards for the warehouse example project in the chapter 5 Appendix.

The labor workhours (input) are accumulated into the appropriate cost account using cost codes and time cards. If the workhours are not accurately recorded in the correct cost account, the cost control system will be ineffective. The accuracy of cost coding workhours is improved by the following:

- Training all personnel in the use of company cost accounts to correctly code time cards.
- Checking time cards for correct cost codes before recording in the cost control system.
- Developing and maintaining a well-documented work breakdown structure.

Measuring Labor Output

The quantities produced are the output of the construction process. Unlike construction inputs that have the common unit of measurement (i.e., dollars and workhours), the output cannot be measured with a common unit of measure. Consequently, a large number of cost accounts are used for construction outputs. Examples of the units of measure for these accounts include cubic yards of excavation, square feet of concrete formwork, tons of structural steel, lineal feet of pipe, and number of electrical terminations.

Cost control requires matching each unit of output to the input (labor dollars) that produced each unit of output. The labor dollars (input) are accumulated into the appropriate cost account in order to match each unit of output to the resources (inputs) that produced the output. The breakdown of the inputs into the individual cost accounts is accomplished by observing and recording the number of workhours expended each day in each cost account. Often the completed work is highlighted on a paper or digital copy of the project drawings. Actual quantities can be easily measured from these marked up drawings. A major consideration for measuring construction quantities is to determine if an item (such as cubic yards of concrete placed or lineal feet of wire pulled) is installed in one step or several steps. Output quantities that are installed in one step are the easiest to measure. The item is either installed or it is not installed. It is more difficult to measure progress when quantities are installed in several steps. One method to measure progress when quantities are installed in several steps is to assign each sequential step its own cost account. However, this would burden the labor cost control system with too many cost accounts. A better way to handle this situation is to use the Equivalent Units method to report the partially completed units as equivalent units completed.

> Equivalent Units is the work-in-process inventory at the end of the period. It is the number of completed units of an item that a contractor could theoretically have produced, given the rules of credit. In short, if 100 units are in process but you have only completed 40% of the work on them, then you are considered to have 40 equivalent units. Adapted from: http://www.accountingtools.com/questions-and-answers/what-are-equivalent-units-of-product

Equivalent Units for each subtask of a cost account are calculated using the following formula:

Equivalent Units = Allowed Credit x Subtask percent complete x Summary quantity

Where the allowed credit (for one subtask) is the analysis of the effort that is required for each subtask of the cost account. The allowed credit is based upon the percentage of the activity's budget dollars or workhours required to complete that subtask. The list of the allowed credit for each subtask of the cost account is called the "rules of credit." The total of the allowed credit for each subtask of the cost account must equal one. Below is an example of the rules of credit for a concrete formwork cost account on a project. Note that the rules of credit may need to be adjusted for individual projects based upon the complexity of the subtasks on that project.

Erect formwork	60% of the work
Remove formwork	30% of the work
Clean & prep formwork	10% of the work

The subtask percent complete is equal to $\frac{\text{actual subtask quantity}}{\text{forecast subtask quantity}}$

The summary quantity is the entire scope of the cost account. The subtask quantities unit of measure may be different the summary quantity. It is the characteristic that represents the total of all subtasks.

Figure 5-3, Daily Production Report, is a record of the work accomplished on the warehouse example project. The quantities that are installed in one step have a single line in the report. The quantities that are installed in several steps have work recorded for each subtask. Figure 5-4, Equivalent Quantity, shows the calculation of the actual output for the cost accounts that have subtasks. The equivalent quantities for each subtask are added to determine the actual output for the cost account.

Account Number	DESCRIPTION	UNIT	Aug 13	Aug 14	Aug 15	Aug 16	Aug 19	Aug 20	Aug 21	Aug 22	Aug 23	Aug 26	Aug 27	Aug 28	Aug 29	Aug 30	Total @ Aug 30
Spread Footings																	
031 11 3455	Erect formwork	SF	176				194				158				180		708
031 11 3455	Remove formwork	SF				176				194				158			528
031 11 3455	Clean & prep formwork	SF				176				194				158			528
032 10 6005	Place rebar	Ton	0.35				0.40				0.32				0.36		1.43
032 30 1756	Set Anchor Bolts	Ea	20				24				18				20		82
033 10 5724	Place concrete	CY		9.0				10.0				8.1				9.2	36.3
Dock Wall Footings																	
031 11 3450	Erect formwork	SF								174				150			324
031 11 3450	Remove formwork	SF											174				174
031 11 3450	Clean & prep formwork	SF											174				174
032 10 6010	Place rebar	Ton								0.64				0.56			1.20
033 10 5719	Place concrete	CY									12.5				11.5		24.0
Dock Walls																	
031 11 4630	Erect formwork	SF													810		810
031 11 4630	Remove formwork	SF															0
031 11 4630	Clean & prep formwork	SF															0
032 10 7020	Place rebar	Ton													0.41		0.41
033 10 6200	Place concrete	CY														22.0	22.0
033 52 9600	Rub walls with grout	SF															0

Figure 5-3 Daily Production Report

Subtask	Subtask Percent Complete Ratio %	Allowed Credit -		Subtask Percent Complete %		Forecast Summary Quantity SF		Equivalent Quantity Completed SF
Spread Footings								
Erect formwork	$\frac{708}{1,410}$ = 50%	0.6	X	50%	X	1,410	=	424.8
Remove formwork	$\frac{528}{1,410}$ = 37%	0.3	X	37%	X	1,410	=	158.4
Clean & prep formwork	$\frac{528}{1,410}$ = 37%	0.1	X	37%	X	1,410	=	52.8
Account Total								636.0
Dock Wall Footings								
Erect formwork	$\frac{324}{324}$ = 100%	0.6	X	100%	X	324	=	194.4
Remove formwork	$\frac{174}{324}$ = 54%	0.3	X	54%	X	324	=	52.2
Clean & prep formwork	$\frac{174}{324}$ = 54%	0.1	X	54%	X	324	=	17.4
Account Total								264.0
Dock Walls								
Erect formwork	$\frac{810}{1,800}$ = 45%	0.6	X	45%	X	1,800	=	486
Remove formwork	0%	0.3	X	0%	X	1,800	=	0
Clean & prep formwork	0%	0.1	X	0%	X	1,800	=	0
Account Total								486.0

Figure 5-4 Equivalent Quantity

Earned Value Method

Once the actual inputs and outputs are measured, the project management team compares the actual inputs and outputs to the project budget inputs and outputs. This comparison occurs at both the cost code and project levels (or at any level in the work breakdown structure). The actual dollars and workhours cost cannot be compared directly to the budget dollars and workhours because the actual is only for completed work whereas the budget dollars and workhours are for the entire project. In the earned value labor cost control system, the actual dollars expended are compared to the portion of the budget dollars for the actual work completed. This portion of the budget is called the earned value and is calculated by multiplying the actual percent complete by the budget.

The following quote appears in the National Institute of Building Science's Whole Building Design Guide. "Earned Value Analysis (EVA) is an industry standard method of measuring a project's progress at any given point in time, forecasting its completion date and final cost, and analyzing variances in the schedule and budget as the project proceeds." (Cullen, 2016)

See the following references for what others say about earned value:

Ashton B. Carter, Former United States Secretary of Defense – Memorandum http://www.acq.osd.mil/evm/docs/PARCA_Authorities_Memo.pdf

Project Management Institute - The use of EVA - earned value analysis in the cost management of construction projects, https://www.pmi.org/learning/library/earned-value-analysis-cost-management-construction-8203

American Society of Civil Engineers - Earned Value Management http://www.asce.org/uploadedFiles/Education_and_Careers/Continuing_Education/Product_Pages/continuing-education/earned-value-management-2015.pdf

Washington State Department of Transportation - Earned Value Management Guidelines, http://www.wsdot.wa.gov/publications/fulltext/PMRS/Guidance_Desktop_Procedures/EarnedValueGuidelines.pdf

U.S. Department of Energy - Earned Value Management, https://energy.gov/em/services/program-management/project-management/earned-value-management

Earned Value Management Definition of Terms

Budget at Completion (BAC) – The dollar amount allocated in the budget to complete a specific scope of work.

$$\textit{Physical \% Complete} = \frac{\text{actual quantity}}{\text{forecast quantity}}$$

Physical % Complete is calculated using the forecast quantity because the forecast quantity is the most accurate predictor of the true quantity of work. If the physical % complete was calculated using the budget quantity the final percent complete would be less than 100% when the true quantity of work was less than the budget and the final percent complete would be more than 100% when the true quantity of work was more than the budget

Earned Value (EV) – The portion of the budget for the work completed

EV = BAC x Physical % Complete

EV can never be more than the BAC

Actual Cost (AC) – The actual cost incurred in accomplishing the work performed within a given time period.

Cost Variance To-Date (CV) = EV – AC

CV > 0 is Good Performance

Cost Performance Index (CPI) = EV/AC

CPI > 1.00 is Good Performance

Estimate at Completion (EAC) – The forecast of most likely final cost. It is determined by predicting the forecast quantity and the overall cost performance at the completion of the cost account. At the start of the project BAC and EAC will be equal. EAC will vary from BAC only when actual costs (AC) vary from the earned value (EV). There are various forecasting techniques to compute the EAC. One of the most common technique is to assume that the performance to date continues such that:

EAC = BAC/CPI

Cost Variance at Completion = EAC – BAC

CV > 0 is Good Performance

		OUTPUT					INPUT			PERFORMANCE				
Account Number	Description	Output Units	Actual Quantity	Forecast Quantity	Physical % Complete	Budget Quantity	Input Units	Budget at Completion	Actual Cost	Earned Value	Cost Variance To-date	Cost Performance Index	Estimate at Completion	Cost Variance at Completion
	Spread Footings													
031 11 3455	Formwork	SF	636	1,410	45.1%	1,410	$	$5,640	$2,496	$2,544	$48	1.019	$5,534	$106
032 10 6005	Place rebar	Ton	1.43	2.80	51.1%	2.80	$	$1,820	$975	$930	-$46	0.953	$1,909	-$89
032 30 1756	Set anchor bolts	Ea	82	160	51.3%	160	$	$1,600	$858	$820	-$38	0.956	$1,674	-$74
033 10 5724	Place concrete	CY	36	72.0	50.4%	72.0	$	$2,160	$1,170	$1,089	-$81	0.931	$2,321	-$161
	Dock Wall Footings													
031 11 3450	Formwork	SF	264	324	81.5%	270	$	$1,080	$858	$880	$22	1.026	$1,053	$27
032 10 6010	Place rebar	Ton	1.20	1.20	100.0%	1.00	$	$650	$663	$650	-$13	0.980	$663	-$13
033 10 5719	Place concrete	CY	24.0	24.0	100.0%	20.0	$	$600	$780	$600	-$180	0.769	$780	-$180
	Dock Walls													
031 11 4630	Formwork	SF	486	1,800	27.0%	1,500	$	$3,750	$975	$1,013	$38	1.038	$3,611	$139
032 10 7020	Place rebar	Ton	0.41	0.96	42.7%	0.80	$	$520	$234	$222	-$12	0.949	$548	-$28
033 10 6200	Place concrete	CY	22.0	50.4	43.7%	42.0	$	$2,100	$936	$917	-$19	0.979	$2,144	-$44
033 52 9600	Rub walls with grout	SF		900	0.0%	750	$	$2,250	$0	$0	$0	1.000	$2,250	$0
	Report Totals				43.6%		$	$22,170	$9,945	$9,664	-$281	0.972	$22,487	-$317

Figure 5-5 Concrete Labor Cost Report

Calculating Earned Value for Example Warehouse Project

In Figure 5-5, Concrete Labor Cost Report, the labor cost performance for the warehouse project is analyzed using the Earned Value method. The detailed description of each field in the Labor Cost Report Using Earned Value Report for cost account 031 11 4630 Dock Walls formwork and for the Report Totals appear below.

Cost Account 031 11 4630 Dock Walls Formwork

The A*ctual Quantity* is transferred to this report from the actual quantities calculated in Figure 5-4 Equivalent Quantity. For cost account 031 11 4630, the actual quantity is calculated to be 486 SF.

The *Forecast Quantity* is the budget quantity plus or minus any changes or corrections. In Figure 5-2, Concrete Forecast Quantities, it was calculated to be 1,800 SF.

The *Physical % Complete* is calculated by dividing the actual quantity by the forecast quantity. $\frac{\text{actual quantity}}{\text{forecast quantity}} = 27.0\%$

The *Budget Quantity* is transferred to this report from Figure 5-1 Concrete Labor Budget. The budget quantity is 1,500 SF.

The *Budget at Completion* is transferred to this report from Figure 5-1 Concrete Labor Budget. The BAC is $3,750.

The *Actual Cost* is collected on the daily time cards, see the Chapter 5 Appendix. For cost account 031 11 4630 there are 25 workhours recorded for the account. See Figure 1-10 for the calculation of the burdened wage rate, $39.00/workhour. The AC is calculated by multiplying the 25 workhours recorded for the account by the $39.00/workhour burdened wage rate = $975.

The E*arned Value* is calculated by multiplying the BAC by the physical % complete. For account 031 11 4630 it is $3,750 multiplied by 27.0%, or $1,013.

The *Cost Variance To-Date* is calculated by subtracting the actual cost from the earned value. For account 031 11 4630 it is $1,013 minus $975, or $38. This is a positive value therefore this is good cost performance.

The *cost performance index* is calculated by dividing the earned value by the actual cost. For cost account 031 11 4630, the CPI is equal to $1,013 divided by $975, or 1.038. This is greater than one and therefore indicates good cost performance.

The *Estimate at Completion* is calculated by dividing the actual cost by the cost performance index assuming that the cost performance to-date will continue until the cost account is completed. For cost account 031 11 4630, the EAC is equal to $3,750 divided by 1.038, or $3,611.

The *Cost Variance at Completion* is calculated by subtracting the estimate at completion from the budget at completion. For account 031 11 4630 it is $3,750 minus $3,611, or $139. This is a positive value therefore this is good cost performance.

Concrete Labor Cost Report Totals

There are no report totals for the Actual Quantity, Budget Quantity, or Forecast Quantity. The sum of the number of anchor bolts, tons of rebar, the square feet of formwork, and cubic yards of concrete would be nonsense.

The report totals for the following categories is the sum of each account for that category. In Figure 5-5 Concrete Labor Cost Report the unit of measure for each of these categories is dollars and therefore these columns can be added together.

Budget at Completion (BAC)
Actual Cost (AC)
Earned Value (EV)
Estimate at Completion (EAC)
Cost Variance To-Date (CV)
Cost Variance at Completion

The R*eport Total Cost Performance Index* (CPI) is a measure of the overall cost performance. It is calculated by dividing the report total EV by the report total AC. Index values greater than one indicate good cost performance. Index values of less than one point towards poor cost performance. For the Warehouse Project, the report total CPI is equal to $22,170 divided by $22,487, or 0.972, which less than one and indicates poor cost performance.

The *Report Total Physical % Complete* formula can be derived from the *EV formula.*

EV = BAC x Physical % Complete
dividing both sides of the equation by the BAC yields
$\frac{\text{EV}}{\text{BAC}}$ = Physical % Complete

Therefore the *Report Total Physical % Complete* is calculated by dividing the report total EV by the report total budget at completion. $\frac{\$9,664}{\$22,170}$ = 43.6%

Concrete Labor Cost Report Analysis

How does Figure 5-5, Concrete Labor Cost Report, control labor costs. By itself the labor cost report does not control anything. What it does do is to identify deviations so that project management can take swift corrective action to minimize labor cost overruns. The labor cost report focusses project management on those cost accounts that need action. The magnitude of the cost performance measures (cost performance index and cost variances) determines the seriousness of the problems so that project management can prioritize their response to the deviations. This procedure is known as management by exception (“Management by Exception,” n.d.)

The major deviations on Figure 5-5, Concrete Labor Cost Report, appear in all three of the “placing concrete” accounts (cost variances at completion = -$161, -$180, & -$44).

This would be the first task for project management to investigate and take corrective action. Also, note the negative variances in the place rebar and set anchor bolts accounts.

In addition to investigating poor cost performance measures in the current report past reports should be examined to look for trends. Indeed, in practice the labor cost report generally has columns for the current period performance as well as for the to date performance.

Summary

Construction labor cost is the most variable component of the project construction budget. Therefore, labor cost control is foremost for profitability for all contractors. This chapter applied the control systems and estimating topics from Chapter 1 to labor cost control.

Effective labor cost control begins with an accurate budget. Each budget cost account contains the budget quantities as well as the budget dollars. During construction actual quantities and actual dollars are measured by cost account and compared to the budget to determine labor cost performance.

Earned value is a useful concept for comparing the actual to the budget. The earned value is that part of the budget for the work completed to date. It is calculated by multiplying the budget dollars by the physical percent complete for each account. This earned value is then compared to the actual cost to date. The difference between the earned value and the actual cost is called the cost variance. The ratio between the earned value and the actual cost is called the cost performance index. These measures are then used to calculate the estimated cost at completion. These metrics allow management to concentrate their efforts on the accounts with poor performance.

References

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