PDHonline Course P159 (3 PDH)

Cost Estimating and Tricks of the Trade - A Practical Approach

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Course Content

Course Introduction

We as engineers, consultants, owner reps, and project managers are frequently asked to provide estimates. How do we go about this? What minimum scoping/design is needed to achieve a stated estimate accuracy? What accuracy can we be reasonably expected to attain at a given scope/design level? This course will answer these questions and provide practical insights to developing meaningful estimates. The course will also offer advice to avoid common pitfalls and exclusions from estimates. This course is filled with practical insight from the Instructor’s considerable experience with both the Consultant and Owner’s perspectives. The course discusses estimates from the earliest stages to those with well-developed scopes.

What is an estimate?

What is an estimate? Many of our customers view an estimate as a menu. For example, before you go to the grocery store, you could make a list of what you want. A gallon of milk, bread, cookies, etc. By simply adding up the individual cost of items you then have an estimate of your bill. However, construction estimating is not that simple. Rarely are two projects identical. Webster defines an estimate as arriving “at an often accurate but usually only approximate statement of the cost of a job to be done.” The Means Illustrated Construction Dictionary defines it more closely for our purposes; “The anticipated cost of materials, labor, equipment, or any combination of these for a proposed construction project.” In real-world
terms, a construction estimate is simply a projection of the likely cost of a project based on an assumption of scope and cost data.

But there are more misconceptions . . .

**Popular Estimating Misconceptions**

Not only do customers (and sadly, some in the profession) oversimplify an estimate, there are many other misconceptions as well that must be dispelled.

- **All you need is a phone** – This can also be referred to as “phone call engineering.” Just call up a vendor or contractor, give a verbal, succinct description of the scope, and they give a highly accurate estimate for you. Wrong. Many projects have failed financially because of this approach. A vendor needs a defined, written scope to evaluate probable costs (except for off-the-shelf items).

- **An exact science** – Actually, estimating is more of an art, but requires a well-rounded knowledge and experience in the profession. Estimating requires instinct based on experience. An estimator will create an estimate with many line items, with the expectation that the whole will be within the expected range of accuracy. A customer might wish to check each line item of an estimate after bids come in, and probably none will be an exact match with received bids. However, statistically, a well-developed estimate should average out closely to the final aggregate bids. Some line items will be high, and others low.

- **Can be perfect on all projects** – Even with experienced and excellent estimators, there will be projects which will be under or over-estimated. As above, estimating isn’t an exact science. There are just too many variables, especially prior to design (scope,
historical relevant costs, market influences, etc.). But as with a good estimate, the sum
total of the estimates should average out.

- Something all engineers are naturally good at – Many customers (as well as
  inexperienced engineers) can make this flawed assumption. Actually, a relatively small
  percentage of professionals, unless specialized, are good at broad-scope estimating (in the
  Instructor’s experience.)

- Something Architectural/Engineering firms are naturally good at – Actually, in the
  Instructor’s experience, the opposite is often true. A/E firms should be excellent in their
  core business – developing scope and design. Often, design disciplines are asked to
  develop an estimate even though they do not have experience or hands-on knowledge of
  market pricing. Later, we will learn a strategy to improve such estimates.

- Can accurately predict bids – Bids can fluctuate wildly even after the design is final.
  There are many dynamics that determine final bid values from subcontractor or vendors.
  These include material pricing arrangements, workload, proximity, etc.

- “It can’t cost that much . . .” – Often, people have a preconceived notion as to what
  something should cost. Budgets can even be set without proper knowledge of the scope.
  However, things simply cost what they cost. The key is to agree to a well-defined scope,
  and then estimate the project.

- Go with the lowest early price – This category is akin to “phone-call engineer.” When
  multiple vendors provide assistance with pricing, be careful of taking the lowest estimate.
  They might not understand the scope adequately, or have performed only a cursory
  review. On the other hand, also be cautious of such estimates when they appear high –
  the vendor could be covering itself.
You should be able to accurately estimate in a hurry – The opposite is true. The accuracy of an estimate is associated with the time to develop it. The time element is more associated with scope development than actually entering cost data in a spreadsheet. It simply takes time to properly determine the scope to a level a reasonable estimate can be developed. (However, no amount of time can improve an estimate if the project design steps aren’t properly developed.) The following chart illustrates this:

**Estimating Time vs. Accuracy**

<table>
<thead>
<tr>
<th></th>
<th>Hours</th>
<th>Days/weeks</th>
<th>Weeks/months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental Scope and Budget</td>
<td>+/- 50%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schematic Design</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preliminary Design/ Design Development</td>
<td>+/- 10%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Now that we’ve learned common misconceptions, let’s look at some truths of estimating.

**The Truths of Estimating**

- What you don’t know will hurt you – Estimating requires a great deal of practical experience to anticipate scope. But even with experience there are simply things that can’t be anticipated. Therefore, we apply contingency at higher percentages early in scope development (to be covered later.)
Difficult, especially renovations – Estimating is a difficult task. One must anticipate scope, plus applied costs. To make the task more difficult, renovations add further challenges. What is buried? Hidden behind a wall?

Requires solid engineering experience as well as cost histories – In order to anticipate scope, one must have not only solid engineering training, but experience in the project type as well. In addition, accurate cost histories of similar work are needed.

Economically influenced – Outside economic influences are generally outside the control of the estimator. There can be unanticipated swings in material and energy costs that can upset a budget. Labor shortages, strikes, and other factors can impact as well.

Projects are one-of-a-kind, custom, without the benefit of a prototype – Product development engineering has the benefit to building prototypes before production. However, facilities and other projects are usually one-of-a-kind. We can’t build it, work the bugs out, and know precisely all the details plus the cost. We must anticipate these.

A discipline that includes all disciplines – An individual estimating a project, when he or she has multidiscipline estimating responsibility, should have a good idea as to other disciplines and general working knowledge.

Important – Estimating is difficult; however, it remains important. We must get it right. The cost of a project can significantly impact the bottom line of an Owner. As well, we are often held accountable for the accuracy of our estimates.

A success measure/metric – A measure of our success is often how accurately we estimated a project. Often, there is little room for error allowed. As noted above, we can be impacted personally in our careers.
Essential to business success – If we overstate an estimate, we could force the Owner not to complete other important projects. If we understate an estimate, we could miss a critical ROI (Return on Investment.) It is simply essential to the health of a business that capital management be effective. In addition, yearly depreciation charges must be considered, which go directly against P&L (Profit and Loss.)

One of our hardest tasks – This should be obvious by now. Estimating is difficult, and is perhaps one of our hardest tasks. While most engineering problems can be quantitatively resolved, estimating requires an element of intuition and experience that often falls in areas less quantifiable.

Sources of Estimating Data

Now we begin the practical portion of the course. Where do we find sources of estimating data that we can use to forecast costs?

- Experience/a “good guess” – Believe it or not, there are times (especially early in a project) that guesses based on experience are appropriate. However, these should be for individual line items and not the entire project unless an identical project was just completed.

- Histories – This is the best and most reliable source of costs for early-stage estimating. Keep track of what projects cost by major subcategories. These will be helpful later. Remember to increase for inflation. We will cover how to do this later.

- Publications (Means, etc.) – There are subscription services that provide cost data. Be careful, however, and add indirect costs.
Contractor databases – These are also very useful. Contractors often keep histories of work that they can use later as sanity checks on proposals and to assist alliance customers with estimates.

Contractors/vendors – Contractors/Vendors can provide early “ball-park” estimates. However, beware of “phone call engineering” mentioned previously. Often, contractors will leave out essential additional costs, such as contingencies, taxes, delivery, fees, permits, design, etc.

Accounting records – You or your customer likely have good records based on accounting standards as to what previous projects cost. In addition, CMMS (Computerized Maintenance Management System) often have the costs embedded in asset records.

Methods of Estimating

Now that we have learned the sources of estimating data, how do we actually perform the estimate? The following are the primary methods of estimating (often called by different names but include similar approaches):

- Benchmarking – This occurs most frequently for projects in their early stages where data exists from recent similar projects. Benchmarking can consist of Rules of Thumb (i.e. $ per ton, packaging line, kwh, person, etc.) that can be applied to your project.

- Squarefoot/Assembly – Squarefoot estimates often also occur early in the project, using historical data to determine current cost. Remember, however, to increase for construction inflation, and to perform a scope gap analysis (add or remove line items for scope differences – rarely are two projects exactly the same.) Assembly estimates can
occur after a bit more scope development, projecting costs for assemblies (equipment, HVAC, utilities, architectural systems, etc.) based on historical data. Often, assembly estimating is safer than unit take-offs, since it is easy to miss an element.

- **Unit takeoff** – This method is often mistakenly overused early in a project. This involves counting up or measuring items, such as lineal feet of pipe, etc. and applying historical unit cost data ($/sf, $/ton, $/lf, $/ea, etc.) – this is similar to assembly estimating but at a more detailed level. This requires a fairly developed design.

- **Proposals/Vendor Estimates** – For this method to be accurate, a well-developed scope and design are also required. Estimates in this category can come from sub-contractor/vendor proposals especially.

- **Actual material and labor detailed estimates** – This is only accurate for well-developed designs, where experienced estimators intimately familiar with the work at hand perform a material take-off and estimate the man-hours to install. Labor rates and material prices are primary to the estimate. Typically, project managers and engineers/architects (asked to be estimators for a day) for a design with low scope development should not attempt this level of an estimate.

- **A good guess/experience (line items)** – There are some things that we just will be unable to get our hands around early, and we will need to guess based on our experience. However, minimize and limit this to line items of an estimate.

- **Most early estimates a combination of the above**

Some estimate methods are better at projecting costs that others as well as require a higher degree of scope development. The following graph illustrates relational accuracies and levels of
scope development. Note the Benchmarking approach can be used with low scope, but has a low corresponding accuracy. However, vendor estimates require a high scope development if there is to be a corresponding high degree of accuracy.

### Forgotten Costs

Leaving things out of an estimate is obviously problematic. Although scope is commonly forgotten, omissions often are the intangibles associated with a project. First, we need to understand Direct versus Indirect costs. Direct Costs are tangible costs associated with vendors, equipment, and sub-contractors. Examples include actual equipment costs, subcontracts, etc. Indirect costs are associated with other requirements necessary to complete the work. These can include construction management/construction fees and overhead/general conditions, design,
pre-operating costs, permits, etc. Unfortunately, people often forget about indirect costs, which can be 10-50% of the Direct Costs! This most often occurs when the “phone call engineering” approach is employed.

The following are specific costs that are sometimes forgotten:

- Taxes
- Delivery
- Rigging
- Equipment Installation
- Insurance
- Design Fees (Rule-of-thumb 6-14% direct construction costs)
- Permit Fees (Rule-of-thumb 1% or higher direct construction costs)
- Premium time (Typicals: Overtime 1.5x, weekend/holiday, 2x)
- Temporary protections/walls
- Mark-up on materials (approx. 10% +)
- FF&E (Furniture, Fixtures & Equipment) – Could represent up to 12% (or higher) of the total cost of an integrated office project
- Utility/Infrastructure
- Sitework
- Data/Telephone
- Commissioning and Qualification (related to Instructor’s Biopharm industry) – Recent experience: 3% or more of the direct const costs
- Construction Management (CM) or General Contractor (GC) Fees and General Conditions – this category includes the following:
o Fee – Applied to Direct Const. Costs and GC’s. This usually is a percent the CM charges to cover the following:
  ▪ Overhead and profit
  ▪ Some home office expenses

o General Conditions (GC’s) – Sometimes, clients mistakenly think the fee will cover the following, but GC’s are usually calculated based on the specific requirements and schedule of the project:
  ▪ On-site staffing, such as superintendent, project manager, etc.
  ▪ Safety supplies
  ▪ Trailer, toilets
  ▪ Dumpster
  ▪ Miscellaneous supplies
  ▪ Temporary site Utilities
  ▪ Other costs associate with managing the subcontractors, etc.

o Rule-of-Thumb: GC’s + Fee = 8-15% direct construction costs

Contingency – what it is used for?

Owner’s often view contingency (if permitted) as a source for a wish list later. Sometimes, thinking estimating is an exact science, Owners will prohibit contingency. However, contingency is necessary if we are to meet our budgets, whether expressly itemized or incorporated into line items. Contingency can be applied to the total project, or most commonly the Direct costs. The following table illustrates the typical applications of contingency. Not that the purposes of contingency vary at each phase, as well as the typical amounts. Depending on
the phase, contingency can be used for scope to some degree, design uncertainties, estimating uncertainties, hidden conditions, and limited human error. Early on, a higher percentage is needed to cover for human error and scope inaccuracies. But later, the contingency should not be primarily used for scope additions. The amounts shown are based on the Instructor’s experience, and area applied to Direct Costs. Pause for a moment, and carefully study the following table.

<table>
<thead>
<tr>
<th>Purpose of Contingency</th>
<th>Fund., Scope and Budget (20-40%)</th>
<th>Schematic Design (15-30%)</th>
<th>Design Development (Preliminary Engineering) (≥10%)</th>
<th>Design Phase (≤10%)</th>
<th>Construction Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scope</td>
<td>X</td>
<td>Minor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Uncertainties (not fundamental scope)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimating Uncertainties</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hidden Conditions</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Human Error</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
As the project progresses, less contingency should be required. The following chart illustrates the relationship between project phase and contingency needed:

Present Value Calculations

It is essential that we include construction inflation when utilizing historical data in an estimate. Often, customers will base an expectation on the cost of a project related to what one cost years ago. Also, estimates must be forecasted to the year in which the project is planned. Warning: don’t use inflation data you hear from the news. Often, construction inflation exceeds this – determine a reasonable rate based on experience in your market, and/or construction journals. When increasing historical costs, use the following formula:
EV = OC * (1 + i)^n

Where

- EV = Estimate Value for the time period of the project
- OC = Original Cost or base year of estimating data
- i = Construction inflation
- n = number of years between the OC and the time the project is to be implemented

**Example 1**

You installed a utility in 2003 that cost $47/sf. You plan to install a similar system in 2007. What should you allocate as the cost/sf using a construction inflation factor of 4%?

Answer: \[ EV = OC \times (1 + i)^n = 47 \times (1 + 0.04)^{2007-2003} = \$55/sf \]

**Example 2**

This approach can also be used to get an initial “ball-park” or order of magnitude (OOM) estimate. For example, in 2008, you wish to construct a 60,000 sf warehouse with an attached 10,000 sf office. In 2004, you built a warehouse for $80/sf. You built an office (fully fitted) in 2003 for 150$/sf. What is the estimate assuming 4%/yr construction inflation?

- Warehouse = 80 * (1 + 0.04)^{(4)} * 60,000 = $5,615,321
- Office = 150 * (1 + 0.04)^{(5)} * 10,000 = $1,824,979
- Total = $7,440,300
(Note: There are dangers with this approach. If the SF’s are not similar, you can experience “economies of scale” distortions. Also, the older the project, the less accurate the extrapolation. Finally, there are typically many gaps that must be rectified – few projects are exactly the same.)

**More Examples**

Let’s apply more of what we’ve learned. This section will illustrate sample estimates similar to those developed by the Instructor for an actual project (prior to design, but for a small project relatively easy for which to develop a scope.) The truth is, most early to mid estimates require a combination of the estimating methods discussed earlier. The following illustrative examples are for the scope of purchasing and installing an industrial piece of equipment, plus the room in which it is to be installed. Note the methods used to arrive at the individual line items. The estimates are for the early phases of a project, where the decision is to be made whether or not to proceed. (Disclaimer: Don’t apply the unit rates to your project. These are for illustration only.)

**Example 3, Equipment**

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Unit Des.</th>
<th>$/unit</th>
<th>Total</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>1</td>
<td>Ea</td>
<td>$</td>
<td>$65,000</td>
<td>Vendor</td>
</tr>
<tr>
<td>600/day technician plus perdiem</td>
<td>5</td>
<td>Days</td>
<td>$600</td>
<td>$3,000</td>
<td>Unit</td>
</tr>
<tr>
<td>VFD</td>
<td>1</td>
<td>Ea</td>
<td>$5,000</td>
<td>$5,000</td>
<td>Unit</td>
</tr>
<tr>
<td>Shipping</td>
<td></td>
<td></td>
<td></td>
<td>$1,500</td>
<td>Vendor</td>
</tr>
<tr>
<td>Taxes and fees</td>
<td>$73,000</td>
<td>Perc</td>
<td>6%</td>
<td>$4,380</td>
<td>Unit</td>
</tr>
<tr>
<td>Electrical connection</td>
<td></td>
<td></td>
<td></td>
<td>$25,000</td>
<td>Vendor</td>
</tr>
<tr>
<td>Conveyor up</td>
<td></td>
<td></td>
<td></td>
<td>$15,000</td>
<td>Vendor</td>
</tr>
<tr>
<td>Auger out</td>
<td></td>
<td></td>
<td></td>
<td>$20,000</td>
<td>Vendor</td>
</tr>
<tr>
<td>Installation</td>
<td></td>
<td></td>
<td></td>
<td>$12,000</td>
<td>Guess</td>
</tr>
<tr>
<td>Rigger</td>
<td></td>
<td></td>
<td></td>
<td>$8,000</td>
<td>Guess</td>
</tr>
</tbody>
</table>
### Example 4, Room for the Equipment

<table>
<thead>
<tr>
<th>Item</th>
<th>Units</th>
<th>Unit Des.</th>
<th>$/unit</th>
<th>Total</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Localized floor drain</td>
<td>1</td>
<td>ea</td>
<td>$15,000</td>
<td>$15,000</td>
<td>Sq. Ft./As.</td>
</tr>
<tr>
<td>Exhaust ventilation</td>
<td></td>
<td>ea</td>
<td>$12,000</td>
<td></td>
<td>Guess</td>
</tr>
<tr>
<td>HVAC modifications</td>
<td></td>
<td>ea</td>
<td>$20,000</td>
<td></td>
<td>Guess</td>
</tr>
<tr>
<td>BMS interface</td>
<td>1</td>
<td>lot</td>
<td>$12,000</td>
<td>$12,000</td>
<td>Sq. Ft./As.</td>
</tr>
<tr>
<td>Room construction (walls, ceiling, doors, etc.)</td>
<td>1000</td>
<td>sf</td>
<td>$74</td>
<td>$73,800</td>
<td>Benchmark</td>
</tr>
<tr>
<td>Demo allowance</td>
<td></td>
<td></td>
<td>$10,000</td>
<td></td>
<td>Guess</td>
</tr>
<tr>
<td>Hose station, wash-down</td>
<td>1</td>
<td>ea</td>
<td>$6000</td>
<td>$6,000</td>
<td>Sq. Ft./As.</td>
</tr>
<tr>
<td>Contingency</td>
<td>$148,800</td>
<td>%</td>
<td>20%</td>
<td>$29,760</td>
<td>Benchmark</td>
</tr>
<tr>
<td>GC's</td>
<td>$148,800</td>
<td>%</td>
<td>12%</td>
<td>$17,856</td>
<td>Benchmark</td>
</tr>
<tr>
<td>Design fees</td>
<td>$148,800</td>
<td>%</td>
<td>10%</td>
<td>$14,880</td>
<td>Benchmark</td>
</tr>
<tr>
<td>Permit fees</td>
<td>$148,800</td>
<td>%</td>
<td>1%</td>
<td>$1,488</td>
<td>Benchmark</td>
</tr>
<tr>
<td><strong>Total, Room</strong></td>
<td></td>
<td></td>
<td></td>
<td>$213,000</td>
<td></td>
</tr>
</tbody>
</table>

### Estimating during the Planning and Design Phases

Now that we’ve learned (or reviewed) the fundamentals of estimating, let’s explore the relationship of estimating to design phases. Estimates are typically required during the planning and design phases of a project. At various levels of planning and design, there are different requirements for levels of scope development and differing reasonable expectations for scope accuracy. The following are the typical steps from project conception until the design is complete. (These steps are often called by different names, but are similar). Steps are covered further in the “Lifecycle” course.
**Fundamental Scope and Budget**

After a project is conceived, the initial planning step is Fundamental Scope and Budget assessment. At this phase, the primary scope is defined with the primary goals. For example, the following are typical decisions made during this phase.

1. Number of units to be produced
2. Approximate size of facilities needed
3. Major equipment identified
4. General approach to fit and finish

The above should be developed from interviews with affected parties. The following documents are generally provided to define the above, and represent only about 2 –5% design completion:

1. Basic scope write-up
2. General Arrangements (floor plans showing major equipment)
Following the scope development, an estimate may be performed. The expected error accuracy for this low level of detail is usually 20-40%. Because of the low level of detail, estimates are usually based on benchmarks (recent similar projects), experience, and some squarefeet extrapolations. A generous contingency of 20-40% should be applied to cover uncertainties including scope, design issues, and estimating accuracies, as well as human error and hidden conditions (especially for renovations – greenfield projects are often easier to estimate). Often, yearly capital budgets are assigned for this level of project scope development but create problems later. If a higher accuracy of estimate is needed, proceed to the next step before establishing the budget.

**Schematic Design**

At this phase, outside architectural/engineering consultants may be employed to assist the Owner (if internal qualified resources are not available), especially for moderate and large-sized projects. This phase builds on the previous, but develops more detail needed to arrive at a better estimate. This often is the ideal level to develop yearly capital budgets. Design documents typically needed at this level represent 5-25% design completion depending on project complexity and typically include the following deliverables:

1. General Arrangement
2. Basic scope write-up
3. P&ID (Piping & Instrumentation Diagrams) and other diagrams
4. Detailed narratives of scope in a standard divisional format (such as CSI), with more detail on materials and fit/finish.
5. Narrative on major utility/infrastructure requirements
6. Draft of any required regulatory scoping documentation

Following development of the above, the cost estimate can be refined further, with a typical expected error of estimate in the 15-30% range depending on project complexity. By this phase, the estimate can be developed with the same resources as in the previous phase, except assembly estimate techniques can also be applied, as well as limited unit take-off and vendor pricing information. However, before final funding requests can be made and we proceed to final design, the next phase should be considered to ensure a more accurate estimate. As before, there should be a pause for a business decision before proceeding. The next phase may cost 1-4% of the total project cost, and should not occur unless there is a business case for proceeding.

**Design Development (Preliminary Engineering)**

In this phase, the design effort continues to develop the scope to the point a highly accurate estimate can be acquired. Some also call this phase preliminary engineering. For some small projects, the next step after conception begins here. At this phase, documents are similar to final construction drawings except specific details and specifications are lacking. The following are the typical design document deliverables by this phase, building on and refining the previous.

1. General Arrangement
2. Basic scope write-up
3. P&ID (Piping & Instrumentation Diagrams) and other diagrams
4. Detailed narratives of scope in a standard divisional format (such as CSI), with more detail on materials and fit/finish.
5. Narrative on major utility/infrastructure requirements

6. Outline Specifications

7. Final draft of any required regulatory scoping documentation

8. Drawings and plans for all disciplines substantially complete without specific details

9. Typical general details

10. Major equipment schedules

The above deliverables represent approximately 20-50% of the design effort (depending on the project complexity), and can result in an error of estimate +/-10%. To arrive at this estimate accuracy, major design decisions/calculations must be complete, and qualified individuals are needed to perform the estimate. Often, A/E firms (Architectural/Engineering) are excellent at assigning scope, but poor at estimating. Conversely, construction firms are often excellent at estimating cost, but poor at assigning scope. Therefore, a good approach is to have both perform an estimate independently, and meet for a budget reconciliation.

Pause at this phase to again ensure the proper business decision to move forward; the next step will typically cost 6-14% of the total project cost (usually less the costs incurred for Design Development.) Complete any “value engineering” or “design to budget” exercises if there are constraints on meeting the scope with an assigned budget.

**Construction Documents (Final Design) – Control Estimate**

In this phase, the design is completed and drawings are finalized to enable permits to be acquired and bids received. Specific details are added to the drawings, they are crosschecked,
and detailed specifications are written. For larger projects, a control estimate may be performed to ensure there hasn’t been “scope creep” and to further refine the previous estimate. Estimates at 90% completion may be 5-10% accurate. Estimates at this phase include detailed unit take-offs and vendor estimates.

The following table summarizes typical rules-of-thumb and approaches at various project scoping/design steps.
Table – Considerations at various stages

<table>
<thead>
<tr>
<th>Element</th>
<th>Fundamental Scope and Budget</th>
<th>Schematic Design</th>
<th>Design Development (Preliminary Design)</th>
<th>Construction Documents (Final Design)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design percent completion</td>
<td>0-5%</td>
<td>5-25%</td>
<td>20-50%</td>
<td>90-100%</td>
</tr>
<tr>
<td>Typical cost as a percent of total</td>
<td></td>
<td></td>
<td>1-5%</td>
<td>6-14%</td>
</tr>
<tr>
<td>Estimate accuracy</td>
<td>20-40%</td>
<td>15-30%</td>
<td>+/-10%</td>
<td>5-10% @ 90% completion</td>
</tr>
<tr>
<td>Contingency</td>
<td>20-40%</td>
<td>15-30%</td>
<td>≥10%</td>
<td>≤10%</td>
</tr>
<tr>
<td>Basic scope write-up</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>General Arrangements</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>P&amp;ID</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Detailed Narratives of scope</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Major equipment schedules</td>
<td>In narrative</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Regulatory documentation</td>
<td>Draft</td>
<td>Final Draft</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Drawings and plans</td>
<td>Without specific details</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Specifications</td>
<td>Outline</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Details</td>
<td>General/typical</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Benchmarking</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Squarefoot</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Assembly</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Unit Takeoff</td>
<td>Limited</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Proposals/Vendor Estimates</td>
<td>Limited</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Material and Labor takeoffs</td>
<td>Limited</td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

Hazards

As we are fairly well along in our course, let’s reemphasize and add additional hazards of estimating, that obviously should be avoided or carefully handled.

- Phone engineering – verbal estimates
- Scope gaps
  - Leaving out “other” costs, only totaling direct construction costs
  - Using previous projects without reconciling or “filling in the gaps”
  - Forgetting escalation (historically 3-6%/yr, some trades higher)
  - Impossible or no schedule; poor project organization
  - Not considering or understanding customer constraints, production demands
  - Not including a multi-discipline team early
  - Treacherous team members – Oh yes, this happens. Some team members working with impunity can have an ulterior motive, or not be willing to be involved appropriately in the beginning and wreck the project at the end with additional requests.
  - Utility support – Are adequate utilities available? If not, estimates for these as well must be included.
  - Treating early estimate as a menu – Parts are usually more costly than the whole if parsed out. Carefully analyze if portions are taken away that could require a larger percentage of Indirect Costs for the remaining or other economies of scale.
  - Limited local qualified resources = higher costs

**Tricks of the Trade/Lessons Learned**

- Have many line items – Early in an estimate, we won’t have the detail. But once scope is available, more line items have a way of stabilizing the overall estimate. Some categories will be high, and others low, but experience has shown that good estimates level out. However, this approach works best when the scope is well defined. If not, you might leave out essential line items, and the estimate could be less accurate.
• Keep good records of previous projects. This will be your most reliable source of historical data, and you will have the best knowledge as to how to apply it.

• On complex jobs, let the A/E and CM both do estimates and reconcile as discussed previously. If you are a project manager, this should be a key take-away from this course. Their initial estimates should be performed independently but using the same scope. Then, follow up with a reconciliation meeting comparing CSI divisions for differences. There will be a healthy tension that should result in a more accurate estimate if properly managed. Why this is needed can be further summarized as follows.
  o CM/GC’s (Construction Managers or General Contractors) may be good at estimating Div’s 1-9, but often poor at 14-17 (MEP or Mechanical, Electrical, Piping) which can account for >1/3 project cost. As well, they are often weak at full scope understanding overall
  o A/E’s are often weak at estimating, but better at scope

• Always do a “ball-park” estimate as a sanity check before accepting estimates from others – estimate it another way, using benchmarks, etc.

• When little detail exists and for large projects, benchmarking-type estimates tend to be more reliable

• Be careful when using benchmark $ from projects on which you are not familiar with the scope

• Recheck mid-way through design – watch out for scope creep or those items left out. It’s better to “take the lumps” early than later.

• Use multiple estimating methods as applicable
 Manage accrual/cashflow by a schedule. Often, customers will budget the entire amount of a project in a year, but there is no way it can be completed in that time frame. With a good estimate, accruals (financial liability) or cashflows (payout) can be accurately measured and forecasted.

 Involve different disciplines in scope planning. Especially involve MEP (Mech. Elect. Piping) trades

 Iron out firm scope as early as possible

 Get help when you need it

 Get an external sanity check! Ask someone else.

 Sleep on it! Let the estimate go a bit stale, then look at it again.

 Use CSI format – The Construction Specification Institute’s divisional format is useful and easily recognizable across the industry and disciplines. In addition, it forces us to think more thoroughly about the line items of the estimate. The following are the major CSI divisions (slightly modified at places by the Instructor):
CSI Format/Divisions – A great way to break out an estimate

- Div. 1: General Conditions
- Div. 2: Sitework & Demolition
- Div. 3: Concrete Work
- Div. 4: Masonry Work
- Div. 5: Metals
- Div. 6: Woods And Plastics
- Div. 7: Thermal & Moisture Protection
- Div. 8: Doors, Windows & Glass
- Div. 9: Finishes
- Div. 10: Specialties
- Div. 11: Equipment
- Div. 12: Furnishings
- Div. 13: Special Construction
- Div. 14: Conveying Systems
- Div. 15: Mechanical
- Div. 16: Electrical
- Div. 17: Controls & BMS

CSI = Construction Specification Institute, the group that developed the divisions

Typical Costs Realized – Categories as a Percent of Total

Because costs vary extensively across regions, time, and industry, this course does not contain specific typical unit costs except for the purposes of example and typical percentages. However, the following table indicates average project costs as a percent of the total for a wide range of industrial, laboratory, and administrative projects (production equipment not included.) Note that the costs are broken down in CSI formats. It is also interesting to note the higher percentage categories. Often, GC’s (General Conditions) will spend considerable effort estimating Divisions 2-13, and underestimate the larger divisions 15-17 (often a third of the cost of the total project). This table is for illustration purposes only, as your specific project may vary. Also remember it is averaged across several representative projects.
<table>
<thead>
<tr>
<th>Category</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Costs</strong></td>
<td></td>
</tr>
<tr>
<td>General Construction (Div. 2-9)</td>
<td>41%</td>
</tr>
<tr>
<td>Furniture, Fixtures, and Equipment (Div. 10-12)</td>
<td>7%</td>
</tr>
<tr>
<td>MEP (Mech., Elect., Piping)</td>
<td>31%</td>
</tr>
<tr>
<td><strong>Indirect Costs</strong></td>
<td></td>
</tr>
<tr>
<td>(Design, GC's, fees, etc.)</td>
<td>21%</td>
</tr>
<tr>
<td><strong>Total Project Cost (Less Production Equipment)</strong></td>
<td>100%</td>
</tr>
</tbody>
</table>

**Course Summary**

In this course we learn practical estimating approaches and theory. Remember to develop scope necessary for the required estimate accuracy, and include all the costs associated with the project. Avoid misconceptions and pitfalls. Apply the tricks-of-the trade. Think “total cost” – Owners typically don’t want only elements of a project with gaps remaining, but need the total. Don’t forget those things often left out!