CENG 6101 Project Management

Estimating and Bidding

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Tools and Techniques for Cost Estimating

- Top-down estimating (Analogous estimating, based on previous projects, conceptual cost estimating)
- Bottom-up estimating (detailed, first principles, lowest elements in WBS)
- Parametric estimating (statistical relationship between historical data and project variables/characteristics)

Basic Elements of Costing Work

- Labour
- Equipment
- Materials – temporary, permanent
- Subcontracts
- Management, Engineering, Supervision
- Project Indirect Costs (Project Overheads)
- Risk and Opportunity (Contingency)
- Corporate Overheads
- Profit

Basic Elements of Costing Work

1. Direct Costs
2. Indirect Costs
    - overheads, preliminaries
3. Risk and Opportunity Allowance
    - contingency
4. Margin/Markup
    = corporate overheads + profit

TENDER PRICE

JOB COST COMPONENTS

		Civil (%)	Building (%)	
Labour		15-25	25-40	
Plant and Equipment		5-10	<5	
Materials	- Permanent - Temporary	50-70 5	60 <5	
Subcontracts		10	Incl.	
SUB TOTAL	**Direct Job Cost**	**100**	**100**	
Management Engineering and Supervision	10-20% DJC	5-15% DJC	5-6% DJC	5-10% DJC
Job Indirect Costs	10-20% DJC	5-10% DJC	3-5% DJC	5-10% DJC
SUB TOTAL	**Total Job Cost**	**TJC**	**TJC**	
Corporate Overheads	7-15% TJC	3-4% TJC	2-3% TJC	3-5% TJC
Profit	7-15% TJC	5-10% TJC	2-5% TJC	3-5% TJC
GRAND TOTAL	**TENDER PRICE**			

Figure 3.05

Steps in Estimating Process

1. Identify bid opportunity: public notices, trades newsletters, trade magazines, invitation to bid
2. Make decision to bid: corporate strategy, need for work, type and location of project, competition
3. Study plans and specifications: review scope, visit site, send out requests for quotations, prepare estimating schedule
4. Break project into work packages – WBS
5. Do quantity takeoff of each work package: record quantity and unit measure
6. Determine construction methods (CMS), equipment and labour requirements (crews)

Steps in Estimating Process

7. Estimate labour and equipment productivity for each operation
8. Obtain and evaluate quotations from subcontractors and suppliers: consider both price and quality of work
9. Price items of work in WBS: direct costs
10. Prepare project schedule
11. Price indirect (overhead) costs: time-based
12. Consider alternatives, “what-if” scenarios
13. Perform risk/opportunity analysis
14. Add corporate overhead and profit margin
15. Spread costs – bid unbalancing, strategic
16. Calculate unit prices and prepare owner’s unit rate schedule or bill of quantities (BOQ)

How Do We Measure Productivity?

- Productivity = $\frac{\text{Output (units of products)}}{\text{Input (Resources)}}$
- Labour Productivity = $\frac{\text{Output (installed qty)}}{\text{Work Hours}}$
- Productivity refers to how efficiently and effectively a company can turn its input (labour and capital) into products and services

Labour Productivity
= units of input (work hours) per unit of output (input/output)
(e.g. 0.5 mhrs/m^3 for placing concrete)
OR
= output/input (e.g. 2 m^3/mhr)

Definition of Productivity

Production
= units of output per unit time
(e.g. 100 m^3/hour for placing concrete,
50 m^2/hour for formwork erection)

Can change production rate by changing number of manhours available in one hour, by changing crew size or shift length

i.e., production (m^3/h)
= productivity (m^3/mhr) * (mhr/h)

Productivity vs. Production

- Production indicates how much work is being done in a given time interval; how fast work is progressing; indicates if schedule objectives will be met; not an indication of how much money is being spent
- Productivity is a measure of *efficiency* of labour and/or equipment crew; indicates if cost objectives will be met

Estimating Direct Costs

RESOURCE CATEGORIES

LABOUR	EQUIPMENT	MATERIALS PERMANENT	MATERIALS TEMPORARY	SUB / SUPPLY CONTRACTS
Labourers	Crane	Concrete	Formwork	Fabrication of structural steel
Carpenters	Grader	Structural Steel	Falsework	Precast concrete
Steelworkers	Scraper	Timber	Curing Blankets	Linemarking
Cement Finishers	Backhoe	Reinforcing Steel	Tarps	Pile Driving

Cost Elements of Labour

- basic wage rate, overtime wage rate
- shift pay differentials
- site allowance, foreman allowance
- travel allowance
- meal allowance (subsistence pay)
- vacation pay, sick pay, statutory holidays
- unemployment insurance, payroll tax
- workers' compensation and other insurance
- retirement savings (pension) plan (optional)
- health insurance (optional)
- Average labour burden: 30% of base wage

EXAMPLE 5.1

An ironworker works 10 hr/day, 6 days/week. A base wage of $20.97 per hour is paid for all straight-time work, 8 hr/day, 5 days/week. An overtime rate of time and one-half is paid for all hours over 8 hr/day, Monday through Friday, and double time is paid for all Saturday work. The social security tax is 7.65 percent, and the unemployment tax is 3 percent of actual wages. The rate for worker's compensation insurance is $12.50 per $100.00 of base wage, and public liability and property damage insurance rate is $3.25 per $100.00 of base wages. Fringe benefits are $3.15 per hour. Calculate the average hourly cost to hire the ironworker.

Estimating Construction Costs, Peurifoy and Oberlender, 2002, McGraw-Hill

Example of Labour Estimate

$$Pay\ Hours = Weekly\ straight\ time + Weekly\ overtime + Saturday\ overtime$$

$$= \left(5\ days\ x\ 8\ \frac{hr}{day} @\ 1.0\right) + \left(5\ days\ x\ 2\ \frac{hr}{day} @\ 1.5\right) + (1\ day\ x\ 10\ hr/day\ x\ 2.0)$$

$$= 40.0 + 15.0 + 20.0$$

$$= 75\ hr$$

$$Actual\ Hours = (10\ hr/day\ x\ 5\ days) + (10\ hr/day\ x\ 1\ day) = 60\ hr$$

$$Average\ Hourly\ Pay = [(Pay\ Hours)\ /\ (Actual\ Hours)]\ x\ Base\ Wage$$

Ironworker Costs:

$$Average\ hourly\ pay = (75/60\ x\ \$20.97/hr = \$26.2125/hr$$

$$Social\ Security\ Tax = 7.65\%\ x\ \$26.2125/hr = \$2.0053/hr$$

$$Unemployment\ Tax = 3.0\%\ x\ \$26.2125/hr = \$0.7864/hr$$

$$Workers'\ compensation = \$12.50/\$100\ x\ \$20.97/hr = \$2.6213/hr$$

$$Public\ Liability/property\ damage = \$3.25/\$100\ x\ \$20.97/hr = \$\ 0.6815/hr$$

$$Fringe\ benefits = \$3.15/hour$$

$$\therefore Ironworker\ average\ hourly\ cost = \frac{\$35.4570}{hr} = \frac{\$35.46}{hr} \cong 1.69 * Base\ wage$$

Cost Elements of Labour

R01100-110 Overtime

One way to improve the completion date of a project or eliminate negative float from a schedule is to compress activity duration times. This can be achieved by increasing the crew size or working overtime with the proposed crew.

To determine the costs of working overtime to compress activity duration times, consider the following examples. Below is an overtime efficiency and cost chart based on a five, six, or seven day week with an eight through twelve hour day. Payroll percentage increases for time and one half and double time are shown for the various working days.

Days per Week	Hours per Day	Production Efficiency					Payroll Cost Factors	
		1 Week	2 Weeks	3 Weeks	4 Weeks	Average 4 Weeks	@ 1-1/2 Times	@ 2 Times
5	8	100%	100%	100%	100%	100 %	100 %	100 %
	9	100	100	95	90	96.25	105.6	111.1
	10	100	95	90	85	91.25	110.0	120.0
	11	95	90	75	65	81.25	113.6	127.3
	12	90	85	70	60	76.25	116.7	133.3
6	8	100	100	95	90	96.25	108.3	116.7
	9	100	95	90	85	92.50	113.0	125.9
	10	95	90	85	80	87.50	116.7	133.3
	11	95	85	70	65	78.75	119.7	139.4
	12	90	80	65	60	73.75	122.2	144.4
7	8	100	95	85	75	88.75	114.3	128.6
	9	95	90	80	70	83.75	118.3	136.5
	10	90	85	75	65	78.75	121.4	142.9
	11	85	80	65	60	72.50	124.0	148.1
	12	85	75	60	55	68.75	126.2	152.4

RS Means

Cost Elements of Owned Equipment

- depreciation cost
- salvage value
- annual ownership cost
- replacement of wearing parts and major overhauls
- routine maintenance cost
- fuel or electricity cost
- operator cost

Cost Elements of Owned Equipment

Capital Recovery Equation

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

where P = purchase price
A = equivalent annual value
i = annual interest rate
n = useful life, in years

The capital recovery equation gives the equivalent annual value (A) of the purchase price (P), assuming an annual interest rate (i) during the useful life of (n).

i = MARR (minimum attractive rate of return) = interest for borrowing money + risk + average cost for taxes, insurance, storage

Estimating Construction Costs, Peurifoy and Oberlender, 2002, McGraw-Hill

Cost Elements of Owned Equipment

Sinking Fund Equation

$$A = F\left[\frac{i}{(1+i)^n - 1}\right]$$

where A = equivalent annual value
F = future salvage value
i = annual interest rate
n = useful life, in years

The sinking fund equation gives the equivalent annual value (A) of the future salvage value (F), assuming an annual interest rate of (i) during the useful life of (n).

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Example of Equipment Estimate

EXAMPLE 5.3

The purchase price of new equipment is $145,000. The estimated salvage value is $25,000 after the end of its expected useful life of 6 years. Assume interest for borrowing money is 9 percent, 5 percent for risk and 3 percent as the equivalent interest rate for taxes, insurance, and storage.

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Example of Equipment Estimate

$$Interest\ Rate\ (i) = 9 + 5 + 3 = 17\%$$

$$Annual\ Ownership\ Cost\ (A) = P\left[\frac{i(1+i)^n}{(1+i)^n-1}\right] - F\left[\frac{i}{(1+i)^n-1}\right]$$

$$A = \$145{,}000\left[\frac{0.17(1+0.17)^6}{(1+0.17)^6-1}\right] - \$25{,}000\left[\frac{0.17}{(1+0.17)^6-1}\right] = \$37,683.48$$

$$Cost\ per\ hour = Annual\ ownership\ cost\ /\ Working\ hours\ per\ year$$

$$Cost\ per\ hour = \$37,683.48/2{,}000\ hours = \$18.84$$

Example of Equipment Estimate

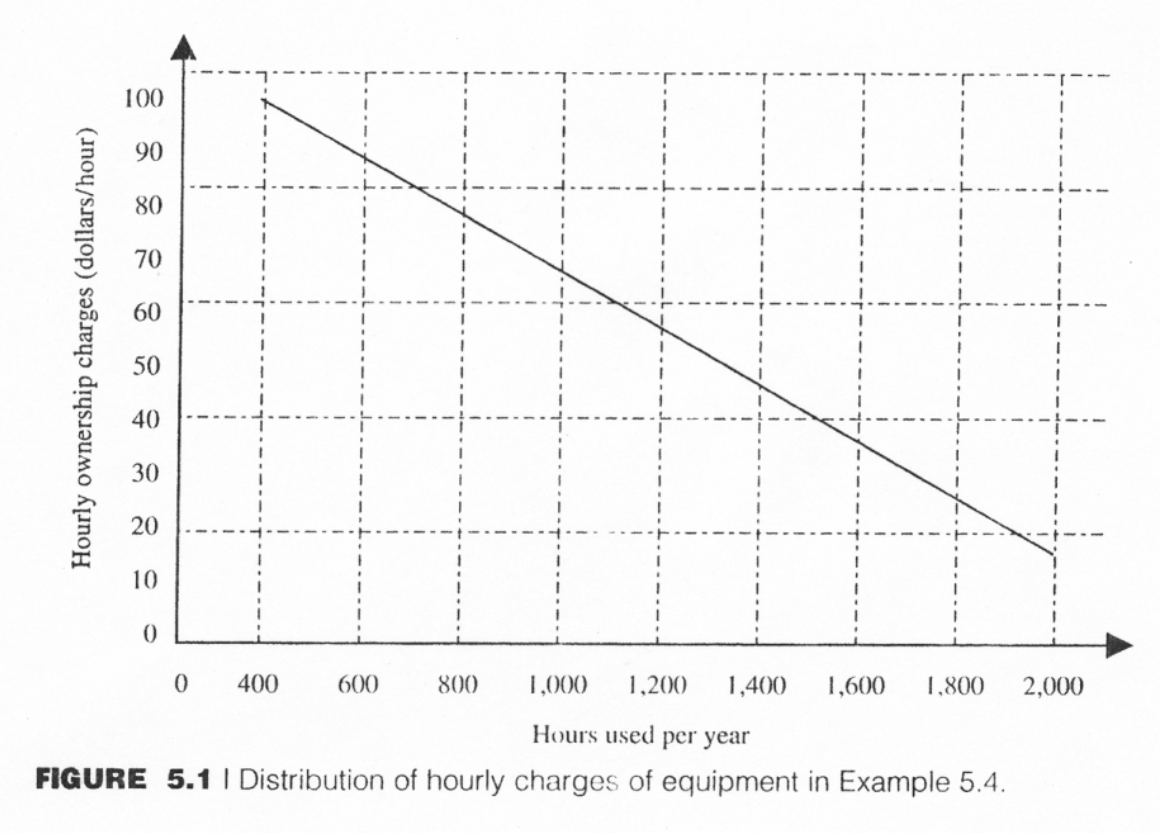

FIGURE 5.1 | Distribution of hourly charges of equipment in Example 5.4.

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Cost Elements of Rented Equipment

- rental rate
- replacement of wearing parts and major overhauls beyond conditions covered by rental rate
- routine maintenance cost
- fuel or electricity cost
- operator cost

Cost Elements of Materials and Subcontracts

Materials (Permanent and Temporary)

- unit cost and quantity
- transportation and delivery cost
- escalation and/or rise and fall

Subcontracts

- unit cost and quantity

ITEM Bridge
QUANTITY 1

Activity	Labour	Equipment Owned	Equipment Rented	Materials Perm.	Materials Temp.	Supply	Subcontr.	Total Cost of Activity
Excavation	4000	8000	0	0	0	0	0	12000
Footings								
Form	1500	500	0	0	6000	0	0	8000
Reinforce	1200	0	600	10000	0	0	0	11800
Concrete	**1600**	**750**	**0**	**2000**	**400**	**11200**	**0**	**15950**
Bridge Deck	3000	2000	1000	5000	1000	0	0	12000
Paving	0	0	0	0	0	0	12000	12000
Sound Barriers	0	0	0	0	0	0	8000	8000
Landscaping	0	0	0	0	0	0	5000	5000
Total Res. Cost of Item	11300	11250	1600	17000	7400	11200	25000	84750
								Total Cost of Item

ACTIVITY Footings
OPERATION Supply, place, finish concrete
QUANTITY 100 m3

Resource Category (1)	Description (2)	Units (3)	Unit Rate ($/unit) (e.g.$/mhr) (4)	Productivity Rate (units/unit qty) (e.g. mhr/m3) (5)	Unit Cost ($/unit qty) (e.g.$/m3) (6) = (4)(5)	Cost ($) (7)=(6)*unit qty (from takeoff)
Labour	Concreters	mhr	32	0.5	16	1600
Supply	Supply concrete	m3	112	1	112	11200
Equipment	Concrete vibrator	hr	10	0.5	5	500
Equipment	Screeds, Trowels, etc.	hr	5	0.5	2.5	250
Materials (Perm.)	Surface curing retarder	m2	5	4	20	2000
Materials (Temp.)	Curing blankets	m2	1	4	4	400
					TOTAL COST	15950

TABLE 1.11 Form to estimate construction costs.

Item no.	Description	Calculations	Number of units	Unit cost	Material cost	Equipment cost	Labor cost	Total cost
2350-0	Furnish and drive 200 creosote-treated piles. Drive piles to full penetration into normal soil. Piles size: 50 ft length, 14-in. butt, 6-in. tip	200 × 50 ft = 10,000 lin ft	10,000 lin ft					
-10	**Materials**							
	Piles; add 5 for possible breakage	205 × 50 ft = 10,250 lin ft	10,250 lin ft	$4.20/lin ft	$43,050			$43,050
-20	**Equipment**							
	Moving to and from the job		lump sum			$7,000		$7,000
	Crane, 12-ton	200 piles/(2½ piles/hr) = 80 hr	80 hr	$145/hr		$11,600		$11,600
	Hammer, single-acting, 15,000 foot pound		80 hr	$15/hr		$1,200		$1,200
	Air compressor equipment		80 hr	$9/hr		$720		$720
	Leads and sundry equipment		80 hr	$5/hr		$400		$400
-30	**Labor**							
-32	(add 16 hr to set up and take down equipment)	80 + 16 = 96 hr						
-32	Foreman	96 hr	96 hr	$25/hr			$2,400	$2,400
-34	Crane operator	96 hr	96 hr	$18/hr			$1,728	$1,728
-36	Laborer (1 total)	96 hr	96 hr	$14/hr			$1,344	$1,344
-38	Workers on hammer (2 total)	96 hr × 2 = 192 hr	192 hr	$15/hr			$2,880	$2,880
-39	Helpers (2 total)	96 hr × 2 = 192 hr	192 hr	$12/hr			$2,304	$2,304
-40	**Subtotal direct costs**				$43,050	$20,920	$10,656	$74,626
-50	**Indirect costs**							
-51	Material taxes							
-511	State sales tax	5% × $43,050						$2,052
-512	County sales tax	1% × $43,050						$431
-520	Labor taxes							
-521	FICA (social security tax)	7.65% × $10,656						$815
-522	Unemployment tax	3% × $10,656						$320
-530	Insurance							
-531	Workman's compensation insurance	9% × $10,656						$959
-532	Contractor's liability insurance	4% × $10,656						$426
-540	Overhead							
-541	Job overhead	8% × $74,626						$5,970
-542	Office overhead	2% × $74,626						$1,493
-60	**Subtotal indirect costs**							$11,651
-70	**Total direct and indirect costs**							$86,277
-80	**Add-ons**							
-811	Contingency	5% × $86,277						$4,314
-812	Profit	10% × $86,277						$8,628
	Subtotal of add-ons							$12,942
-90	Performance bond	1% × ($86,277 + $12,942)						$922
-91	**Total cost,** amount of bid	$86,277 + $12,942 + $922						$100,141
-92	Cost per lin ft	$100,141/10,000 lin ft						$10.01 per lin ft

Estimating Construction Costs, Peurifoy and Oberlender, 2002, McGraw-Hill

PRELIMINARIES
PROJECT OVERHEAD COSTS
INDIRECT COSTS

FIXED COSTS:

Mobilisation

- Building and planning authority fees
- Administration finance charges
- Fees for provision of guarantees and bonds
- Insurance premiums
- Setting out work (surveying)
- Purchasing and setting up of site offices and sheds
- Purchasing of wet weather gear and safety equipment
- Building temporary roads
- Installation of fencing around site
- Transportation of personnel (to remote site)
- Installation of utilities

Demobilisation

- Dismantling and removal of site offices and sheds
- Dismantling and removal of fencing
- Cleaning up of site
- Dismantling and transportation of plant and equipment (e.g. cranes)
- Transportation of personnel (from remote site)
- Provision of warranties to client
- Provision of shop drawings, as-built drawings, schedules, cash flow, and manuals to client
- Salvage recovery from sale of site equipment
- Maintenance during defects liability period

PRELIMINARIES
PROJECT OVERHEAD COSTS
INDIRECT COSTS

RECURRING COSTS:

Based on project schedule

- Salaries of site supervisors, engineers, project managers, safety officers, site secretaries
- Salaries of general field staff
- Rental, maintenance, and running of vehicles for site personnel
- Consumables: coffee/tea, first aid supplies
- Small tool consumables
- Running of utilities: water, electricity, gas
- Communication facilities: telephones, mobile telephones, faxes, couriers, postage
- Site administration
- Site rubbish disposal
- Accommodation of site personnel (on remote site)
- Minor plant and equipment hire (e.g. drills, jackhammers)
- Major plant and equipment hire (e.g. cranes)
- Fuel and maintenance costs for plant and equipment
- Periodic inspections and testing
- Maintenance of site records
- Design and documentation coordination and production
- Financing costs
- Retention amounts
- Accident payments
- Taxes and duties

Estimating Vs. Tendering

ESTIMATING:

- Assessing direct costs and indirect costs

TENDERING/BIDDING:

- Assessing risk and opportunity allowance and margin

RISK AND OPPORTUNITY ASSESSMENT:

- Identifying and assessing the impact on costs of potential project risks (monetary losses) and opportunities (monetary gains)

Factors affecting Risk and Opportunity Allowance

Project Characteristics

Size of project (dollar value)

Duration of contract period

Location with respect to head or branch office

Design Characteristics

Degree of contractor involvement in design phase

Proportion of design complete at time of tendering

Confidence in design

Company relationship with design team and consultants

Cost Estimate Characteristics

Time allowed for submitting bids

Proportion of time-based overheads to contract value

Amount of negative cashflow on project

Amount of external financing required for project

Liklihood of escalation and/or rise and fall

Liklihood of changes in labour market supply

Liklihood of increase in foreign exchange rates

Subcontractors and Suppliers

Proportion of work ($) subcontracted to total contract value

Number of major supply and/or subcontracts on project

Lack of guaranteed price over duration of supply/subcontracts

Liklihood of negotiating lower price on supply/subcontracts

Quality of work and credit worthiness of subcontractors/suppliers

Current workload of subcontractors and/or suppliers

Company's relationship with subcontractors/suppliers

Company's quoted prices from subcontractors/suppliers with respect to competitors:

- Commercial advantages
- Commerial disadvantages

Project-Related Risks

Likelihood of unexpected climatic conditions

Likelihood of unexpected job site conditions

Degree of safety hazard on project

Completeness and clarity of tender documents and specifications

Amount of contractor coverage (e.g. latent conditions clause)

Amount of liquidated damages

Likelihood of regulatory restrictions causing delays

Complexity in project design

Complexity in construction methods

Likelihood of a schedule delay

Uncertainty in estimated quantities, productivity, and/or price rates for:

- Labour
- Plant
- Materials

Proportion of labour cost to total project cost

Proportion of hired to owned plant on project

Material delivery reliability

Project-Related Opportunities

Innovation in design

Innovation in construction methods

Amount of contract bonuses

Likelihood of an acceleration in schedule

Likelihood of changes in contract:

- Scope
- Conditions
- Quantities
- Rates

Risk and Opportunity Assessment

- Identify items in the project which may have potential cost overruns (risks) or cost savings (opportunities)
- Assess the most likely $ cost or savings associated with each item
- Assess the probability of each cost or savings occurring
- Multiply the $ cost or savings by its probability of occurrence
- Sum up the total resultant costs and the total resultant savings; the difference between the two is the net project risk/opportunity allowance (contingency) (may be + or -)

Risk Factors

- Unexpected climatic conditions
- Unexpected geological or soil conditions
- Uncertainty in estimated productivity
- Delay in schedule
- Delay in delivery of materials

Opportunity Factors

- Innovation in project design or construction methods
- Negotiated deals with supplier(s)
- Acceleration in schedule
- Changes in contract scope

Other Methods of R/O Assessment

- By cost category breakdown, to reflect amount of risk inherent in each category: labour, equipment, materials, subcontracts
- Using “what-if” scenarios – best, most likely, worst
- Included in direct job cost items
- Included in margin (markup)
- Risk analysis modeling, e.g. using @RISK and Monte Carlo Simulation

Margin/Markup Assessment

- Must at least cover corporate overheads, based on budgeted turnover
- Depends on the objectives of the company in tendering
- Depends on the amount of risk/opportunity assigned
- Depends on conditions within the company, advantages and disadvantages, client, competition, state of the market, economy

Items Covered by Markup

- Corporate overheads
- Profit
- Risk and opportunity allowance (in some cases)

Objectives in Tendering

- To win the project
- To meet budgeted turnover requirements; to deploy idle resources
- To be seen as competitive; to build a reputation
- To break into a new market; strategic value
- To test a new geographical area
- To maximize project's contribution to profit

Objectives of this Tender

A company may have more than one objective in tendering. Although a company aims to win every project it bids, winning may or may not be the primary or only objective.

For example, it may be very important to a company **to win the project** if, for example, it needs **to generate turnover to meet the corporate budget, or it needs to deploy idle resources**. A company may also have a desire **to be seen as competitive and/or to build a reputation with the client and/or with consultants**. Another objective may be **to break into a new market and/or to win the project for its strategic value**. In each of these cases, the company may bid the project at the lowest acceptable margin, to increase its chances of winning.

A second scenario exists when a company is tendering **to test a new geographical area** in which it will be bidding for several projects, and it wishes **to give its estimating team experience in the new area**. In this case, the company may bid the job with a medium size margin in order to assess its position relative to its competitors for the project.

Another objective in tendering may be **to maximise the project's contribution to profit**. In this case, the company may have a sufficient amount of work on hand and may already be seen as a major competitor in this market; however, it may be bidding to maintain its feel for the market and to remain competitive. The company will therefore bid the job at a relatively high margin, so that if it wins, it can anticipate a large profit on the job and cover the premium it will have to pay to perform the excess work.

Any combination of these objectives is possible on any given tender.

1. **To win the project**
2. **To meet budgeted turnover requirements and/or to deploy idle resources**
3. **To be seen as competitive and/or to build a reputation with the client and/or with consultants**
4. **To break into a new market, or for the strategic value of the project**
5. **To test a new geographical area, and to give the estimating team experience in the new area**
6. **To maximise the project's contribution to profit**

Factors Influencing Markup Size

- Need for work
- Desire for project
- Amount of competition
- Market conditions
- Magnitude of risks and opportunities
- Relationship with client
- Strategic value of project
- Likelihood of follow-on work
- Complexity of project
- Previous experience of contractor
- Quality of estimate

Factors Affecting Margin Size

Company Characteristics

Need for work

Desire for project

Likelihood of winning project

Availability of other projects over remainder of fiscal year

Likelihood of winning future tenders over remainder of fiscal year

Targeting of more desirable projects over remainder of fiscal year

Capacity to supply resources for construction

Availability of key personnel (management) in company

Capacity to supply resources for financing

Company's strength in the industry

Experience on similar projects

Past profit on similar projects

Familiarity with geographical area

Familiarity with market

Amount of contingency (risk/opportunity allowance) in estimate

Corporate and Budgetary Considerations

Margin required of project by corporate budget

Rate of return required from investment in project

Tax liabilities of project

Proportion of fiscal year already over

Actual versus budgeted turnover to date

Actual versus budgeted corporate overheads to date

Actual versus projected amount of work won to date

Corporate strategy or business plan for this market

The Client

Company's relationship with the client

Major competitors' relationship with the client

Credit worthiness and fairness of the client

Competition

Number of competitors for the project

Competitors' current workload in this market

Number of competitors with strong desire for this project

Likelihood of any of competitors having an advantage in:

- Design
- Construction methods
- Labour productivity
- Plant
- Materials

Previous experience of competitors on similar projects

Competitors' performance on past projects in this market

Competitors' ranking in past bids in this market

Competitors' current workload in other markets

Economic and Political Conditions

Current state of the economy

Current unemployment rate

Current interest rates

Likelihood of increase in interest rates

Likelihood of changes in tax laws

Expected market trend in this sector of industry

Amount of work available to contractors in this sector of industry

Amount of other work available to subcontractors and/or suppliers on this project

Methods of Setting Markup

- Based on minimum or base margin - break even analysis
- Based on resource cost category breakdown (to reflect risks inherent in each)
- Based on experience and market conditions

Break Even Analysis

To determine minimum (base) markup

OR

To determine minimum volume of work (turnover) for firm to break even (i.e. to cover corporate overhead costs, without making any profit).

Method A:

Predict turnover level ($) for coming year and calculate minimum markup (%).

Method B:

Determine gross markup (%) (i.e. profit plus corporate overheads) on projects in coming year and calculate minimum volume of work (turnover) ($).

Steps in Break Even Analysis

Forecast corporate overheads for coming year:

Previous year = $200,000
10% inflation = $20,000
(can be applied before or after firm growth)
Firm growth = $20,000

→Forecasted corporate overheads $240,000

Steps in Break Even Analysis

Method A:

- Forecast turnover level, e.g. $2,000,000
- Minimum Markup

  = Corporate Overheads / Turnover

  = $240,000/$2,000,000

  = 12%

Method B:

- Forecast gross markup, e.g. 12%
- Use break even analysis equations:

Revenue - Project Costs = Gross Profit [1]

Gross Profit - Corporate Overheads = Net Profit [2]

Gross Profit / Revenue = Gross Markup [3]

Steps in Break Even Analysis

At Break Even point, Net Profit = 0, so:

From [2], Gross profit = Corporate Overheads

From [1], Revenue = Project Costs + Corporate Overheads

From [3], Corporate Overheads / Revenue = Gross Markup

Revenue = Corporate Overheads/Gross Markup

In our example:

Revenue = $240,000 / 0.12 = $2,000,000

Methods of Spreading Additional Costs Over Bill Items

1. **Evenly, in proportion to direct cost of each bill item**

Bill Item	Direct Cost	Spread Amount
1	$ 400, 000	$ 4000
2	$ 200, 000	$ 2000
3	$ 100, 000	$ 1000
4	$ 300,000	$ 3000
Total	$1, 000, 000	$10, 000

2. **Front-end loading of bid**
   - **to reduce project financing costs**

3. **Strategically**
   - **to profit from client's errors**

Provisional and Prime Cost Items

PROVISIONAL QUANTITIES:

- For work which may or may not occur, or
- Where variations are expected in quantities
- Safer not to allocate overhead or contingency (R/O) spread to these items, since they may or may not occur and/or final amounts unknown

PRIME COST ITEMS:

- Owner-stipulated sum of money, adopted by all bidders, for work not yet fully detailed
- Amount specified can not be modified by bidders
- Spread overhead (indirect costs) and contingency to all items *except* provisional and prime cost items
- Use provisional and prime cost items to calculate markup (margin), but spread markup to all items *except* prime cost items

Strategic Spreading

- For unit price contracts: paid on basis of actual quantities installed
- Strategic spreading to benefit from errors in owner's quantities
- Increase unit prices of items that are underestimated by owner (load these items)
- Decrease unit prices of items that are overestimated by owner
- Can be used to (1) reduce overall bid price to be more competitive, or (2) to increase profit margin while maintaining original bid price

TENDER SUMMARY

Bill Item	Description	Quantity			Labour	Temp Material	Perm Material	Owned Equipt	Rented Equipt	Subs	Total DC	IDC Spread	Subtotal Cost	Conting. Spread	Margin Spread	Total Bid Price	Final Bid	
		Bill	Est	Unit													Bid Rate	Bid Price
1.1	River Diversion	1	1	LS	35000	5000	50000	100000	16000	0	206000	300000	506000	400000	54314	960314	960314	960314
2.1	Excavate Foundations	77000	80000	m3	316300	154000	0	450000	135600	0	1055900	450000	1505900	100000	161642	1767542	22.96	1767542
8.1	Excavate rock and deliver	320000	350000	m3	1591000	1878000	0	473000	1000000	0	4942000	600000	5542000	0	594873	6136873	19.18	6136873
16.1	Dirll grout holes-provis.	600	600	m	33600	7400	0	38000	0	0	79000	0	79000	0	8480	87480	145.80	87480
16.2	Grouting - provisional	2000	2000	bags	148400	0	37600	112000	0	0	298000	0	298000	0	31987	329987	164.99	329987
17.1	Metalwork - prime cost	1	1	LS	0	0	0	0	0	600000	600000	0	600000	0	0	600000	600000	600000
20.1	Concrete in pier shafts	460	485	m3	16435	6280	58200	0	9950	3700	94565	150000	244565	0	26251	270816	588.73	270816
	TOTALS				2140735	2050680	145800	1173000	1161550	603700	7275465	1500000	8775465	500000	877547	10153012		10153012

Indirect costs = 1500000
Contingency = 500000
Indirect costs and contingency spread to front-end load bid
Margin = 10% of subtotal costs = 0.10x8775465 = 877547
Total subtotal cost of items that receive margin spread = 8775465-600000 = 8175465

Example of front-end loading of bid prices

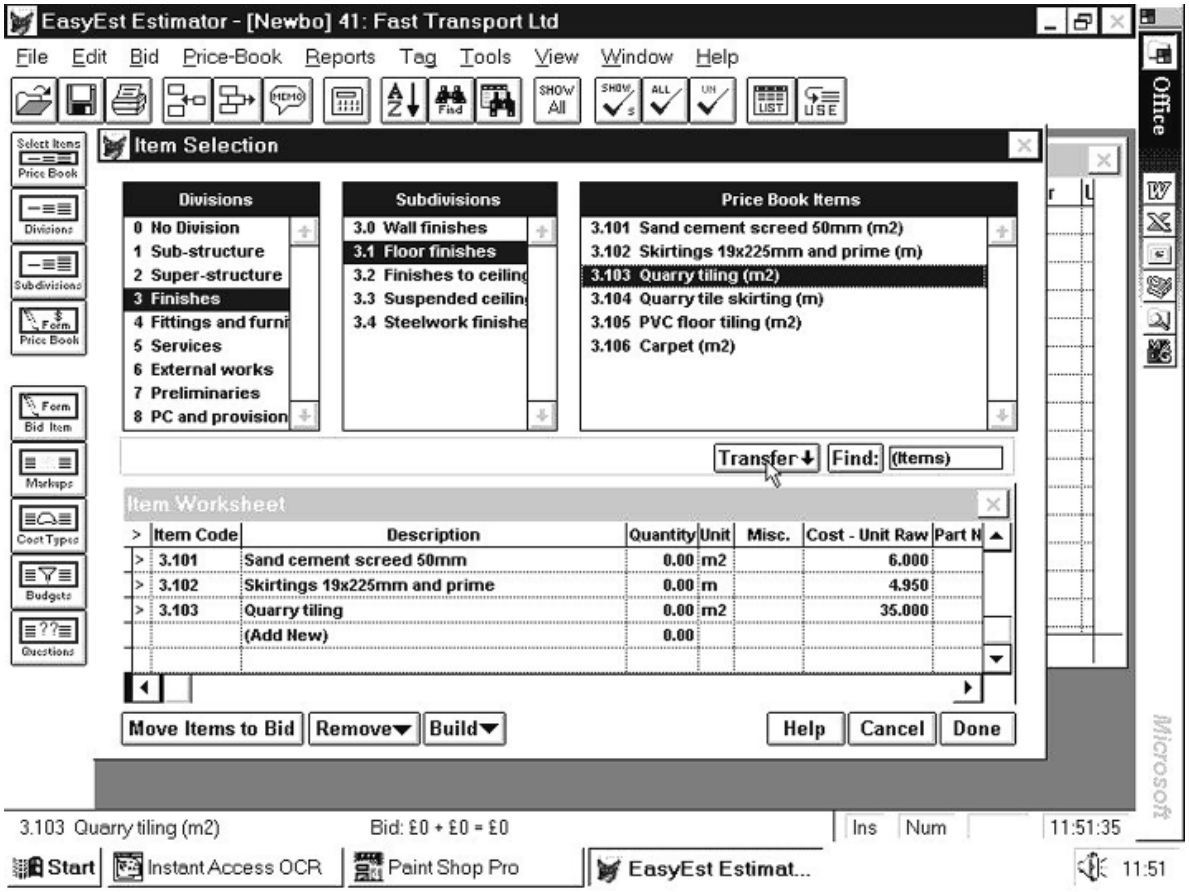
Computer-Aided Estimation

- Software application for common estimating tasks:

Application	Spreadsheet	Word processor	Database	Specialist package
Cost planning	X		X	X
Tender register	X	X	X	
List sub-contractors and suppliers	X	X	X	X
Enquiry letters		X	X	
Resource price lists	X		X	X
Calculate all-in rates	X			X
Produce standard bills for repetitious work	X			X
Bar schedules	X			X
Rate build-ups	X			X
Extend and total bills of quantity	X			X
Lists of company staff costs and plant	X			X
Calculate costs of fluctuations	X			X
Adjust for late quotations	X			X
Calculate/plot cashflow analysis	X			
Reports for management	X			X
Adjust individual resources				X
Adjust/distribute mark-up on rates	X			X
Gross bill for client	X			X
Bill of allowances for construction	X			X

Computer-Aided Estimation

- Easy Estimator Software:



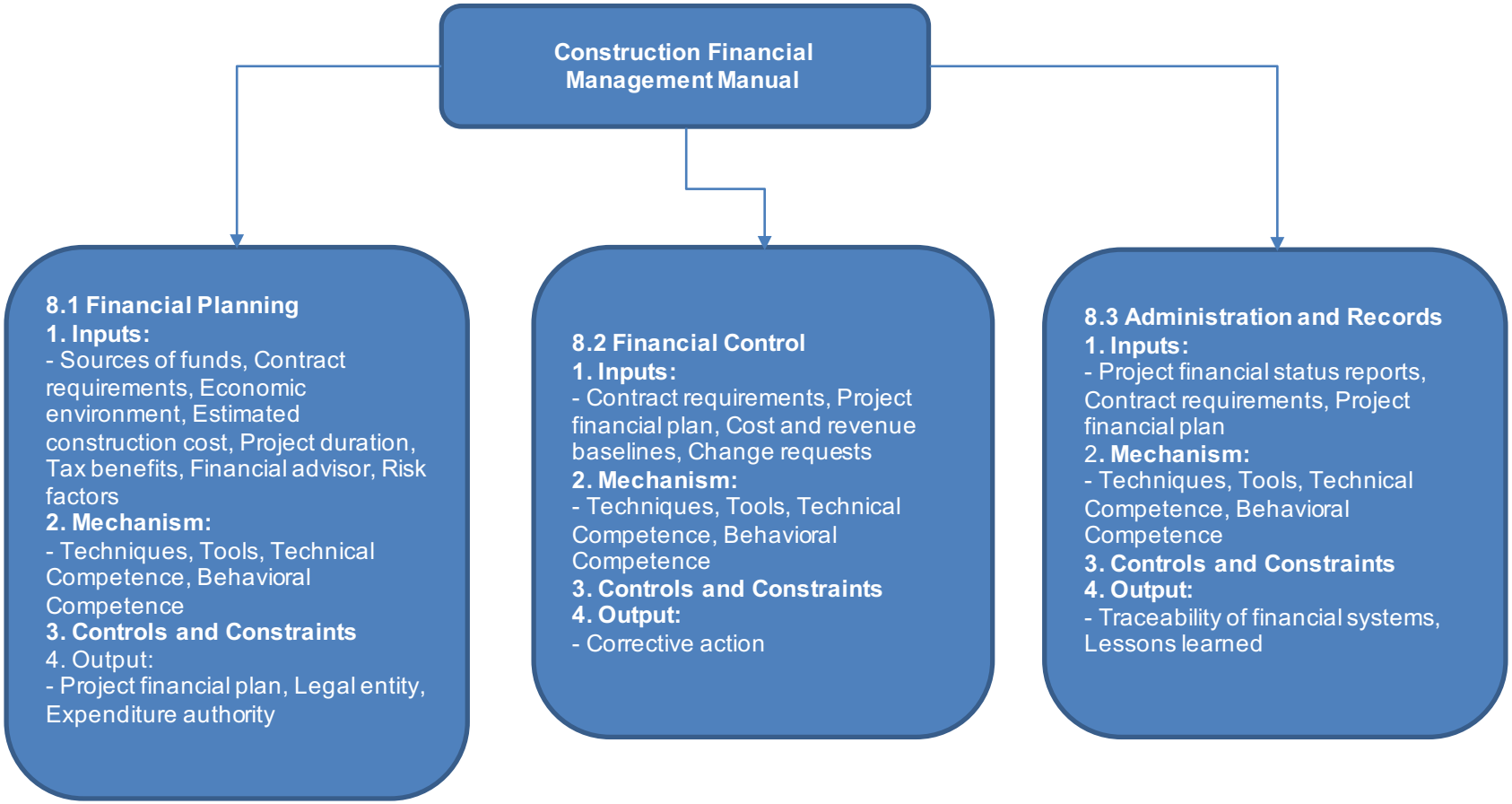
- RSMeans:

Construction Financial Management

- Financial management includes the processes to acquire and manage the financial resources for the project.
- It is more concerned with revenue source and analyzing/updating net cash flows for the construction project than is cost management.
- Client typically pays for the cost of the project by means of periodic or interim progress payments to both the consultant and contractor.
- Accordingly, the client needs to have the necessary financial management processes in place so as to secure and manage the financial responsibilities of the projects.
- The consultant has to finance the initial costs of hiring employees and in case of supervisions works, the consultant has to finance the monthly expenses of employees. Same is the case for the Contractors.

Construction Financial Management

- Contractors or consultants are able to finance this using advance payments or by themselves or can obtain a short term loan to cover this initial period.

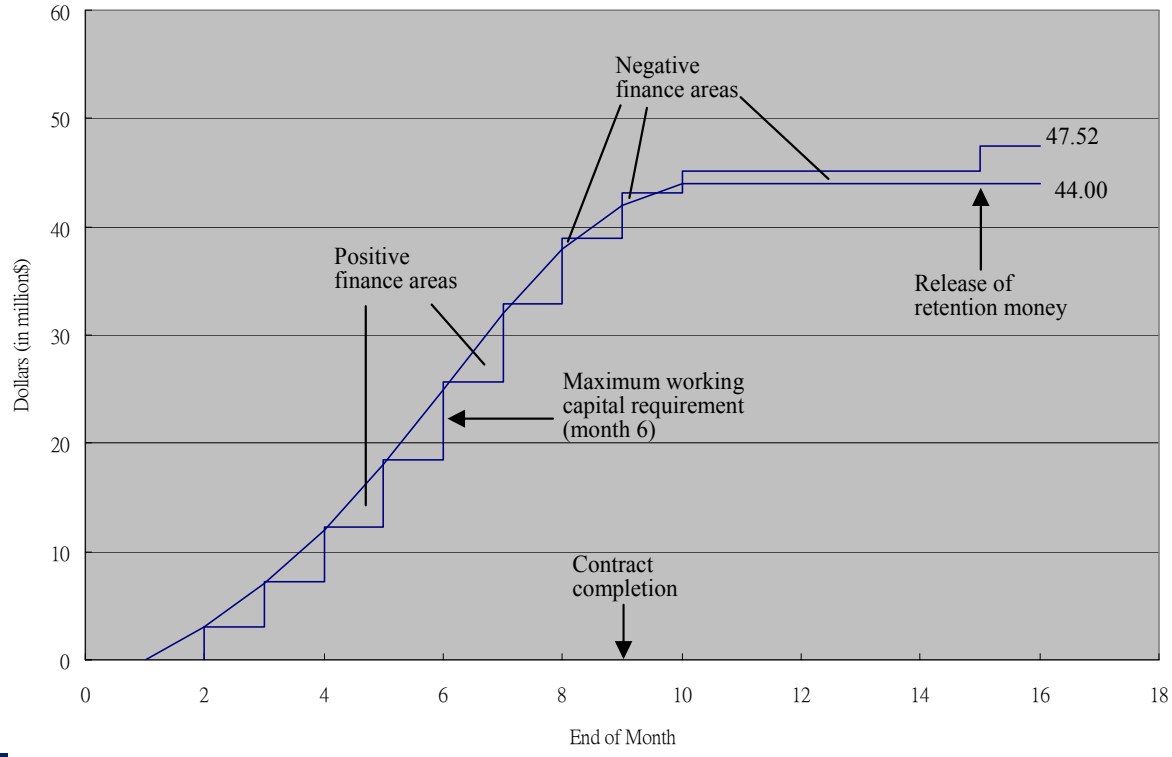


Project Cash Flow Analysis

- Cash flow measurement is a prime way of determining the need for financing needs of a construction project.
- Construction contractors rely on cash inflow to balance out the costs incurred in order to keep financial costs to a minimum.
- Money outflow is basically the scheduled payments for the sub-contractors, vendors, and fees, insurance, taxes, salaries for direct labor and support staff, and the cost of financing.
- Working capital for construction projects represents the excess between the current assets assigned to the project over current liabilities of the project.

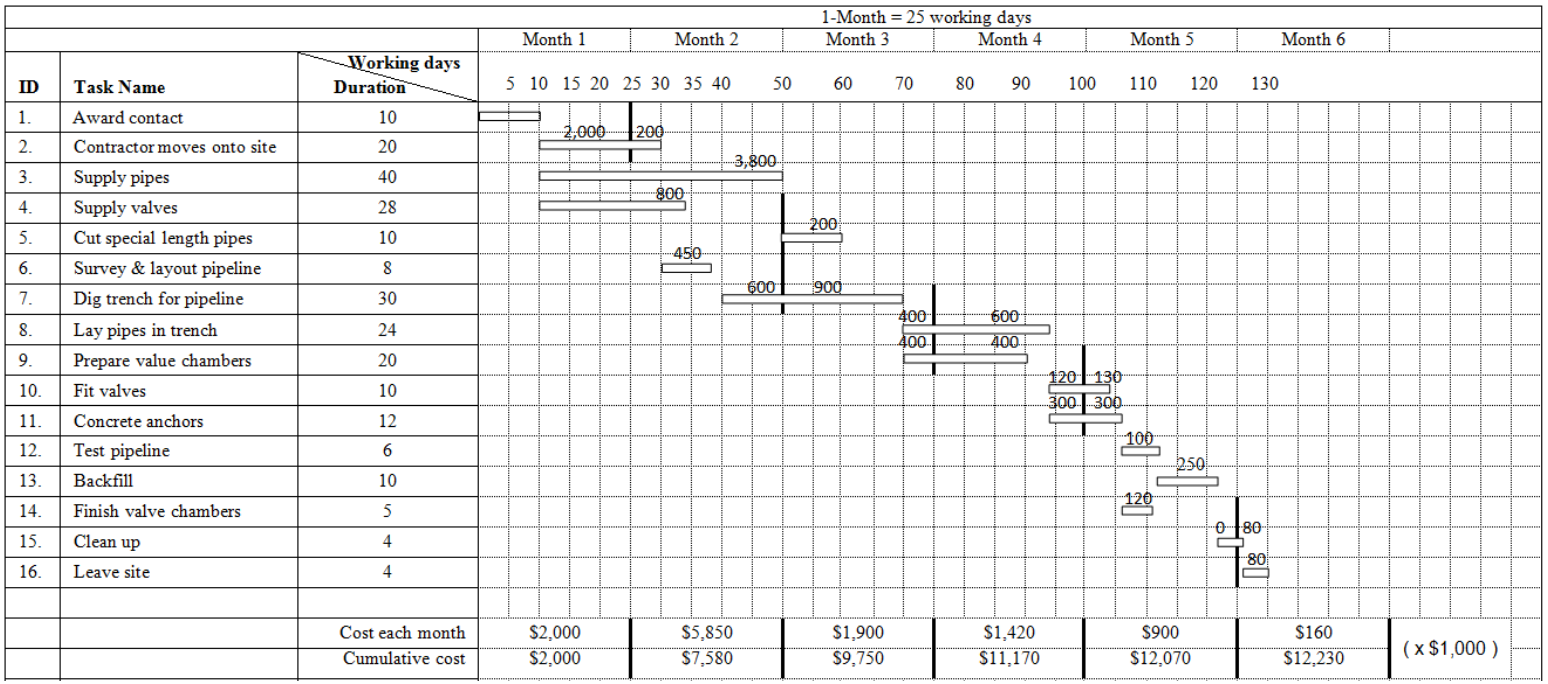
Project Cash Flow Analysis

- The maximum working capital needed for construction projects is determined by taking the vertical differences between the S-Curve and the Cumulative interim payment graphs. The working capital analysis shall cover the construction as well as the defect liability period.



Project Cash Flow Analysis

- Consider a construction project having a total of 16 activities. The contract completion date of the project is 5 months and 5 days and the defect liability period is 3 months. The contract specified a 2.5% retention which can be released at the end of the 8 month.



1-Month = 25 working days

ID	Task Name	Working days / Duration	Month 1	Month 2	Month 3	Month 4	Month 5	Month 6
			5 10 15 20 25	30 35 40	50 60 70	80 90 100	110 120	130
1.	Award contact	10						
2.	Contractor moves onto site	20	2,000	200				
3.	Supply pipes	40		3,800				
4.	Supply valves	28		800				
5.	Cut special length pipes	10			200			
6.	Survey & layout pipeline	8		450				
7.	Dig trench for pipeline	30		600	900			
8.	Lay pipes in trench	24			400	600		
9.	Prepare value chambers	20			400	400		
10.	Fit valves	10				120	130	
11.	Concrete anchors	12				300	300	
12.	Test pipeline	6					100	
13.	Backfill	10					250	
14.	Finish valve chambers	5					120	
15.	Clean up	4					0	80
16.	Leave site	4						80
		Cost each month	$2,000	$5,850	$1,900	$1,420	$900	$160
		Cumulative cost	$2,000	$7,580	$9,750	$11,170	$12,070	$12,230

(x $1,000)

Project Cash Flow Analysis

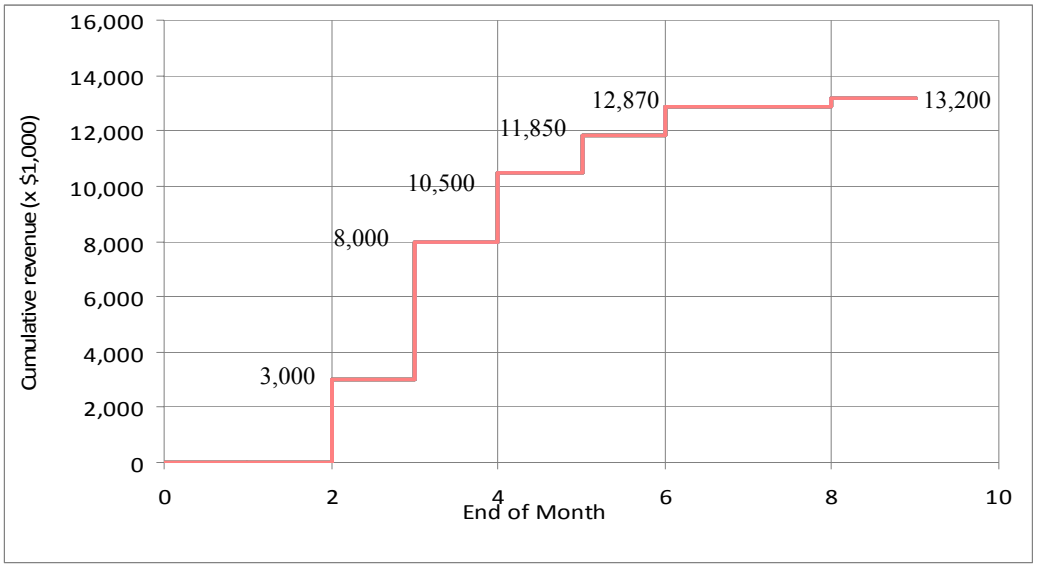
- **Develop S-Curve**: The S-curve is derived by summing the cost of each task in given month.

- **Develop of Cumulative Interim Payment Graph:** The length of the period is usually made based on the specified minimum amount for interim payment.
- Suppose for the project shown above, the interim payments are effected on monthly basis:

Project Cash Flow Analysis

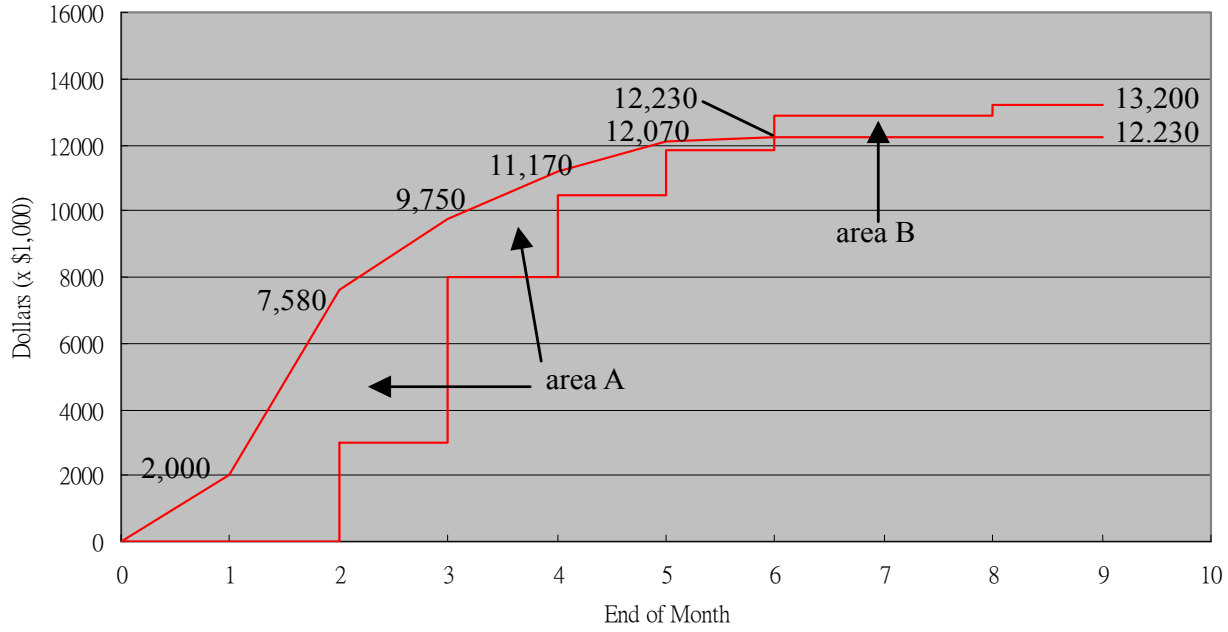
- **Development of Cumulative Interim Payment Graph**

End of month	2	3	4	5	6	7	8
Payment ('000)	3,000	5,000	2,500	1,350	1,020	0	330
Cumulative payment ('000)	3,000	8,000	10,500	11,850	12,870	12,870	13,200



Project Cash Flow Analysis

- **Working Capital Requirement Analysis:** The S-Curve with the interim payment graph are combined to be shown in one diagram, and the graph provides the maximum working capital needs of the project.



- Largest vertical difference occurs immediately before the end of month 2, and the maximum amount of working capital required is $7,580,000 for the project.

Assignment

- Read and be prepared to discuss:
- Mak, S. and Picken, D. (2000). Using Risk Analysis to Determine Construction Project Contingencies. Journal of Construction Engineering and Management, 126(2): 130-136.

References:

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- Estimating Construction Costs, Peurifoy and Oberlender, 2002, McGraw-Hill.
- Tang, S.L. (2014). *Construction Financial Management*. 2nd edition, bookboon.com.
- Brook, M. (2004). Estimating and Tendering for Construction Work. 3rd edition, Elsevier Ltd.