PEARSON NEW INTERNATIONAL EDITION

Computer-Based Construction Project Management

Tarek Hegazy

First Edition

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4.3.3 Total Indirect Cost Once the template of Figure 12 is filled, the total indirect cost is obtained by adding up the project overhead and the general overhead components. The total indirect cost can then be expressed in the following straight line relationship:

Total Indirect = **a + b X**
= **Fixed Indirects** + **Variable Indirects ($/day) x Project Duration**

4.4 Finalizing a Bid Proposal

When the O&P is added to the estimate as percentages for labor, equipment, material, and subcontractors costs, as in the R.S. Means approach, the O&P become fairly distributed among the contract items and the final bid can be easily summed. On the other hand, when the direct and indirect costs are calculated separately, as explained in the previous section, two more steps are needed to finalize the bid: (a) estimating a proper markup percentage to cover for profit and risk contingency; and (b) adding all the cost components to formulate the final bid.

The markup is usually assessed at what is considered to be possible in the prevailing market conditions. However, the following factors should be taken into consideration when deciding the markup:

- Competition.
- Contractor's desire for work.
- Level of project uncertainty.
- Project type, size, and complexity.
- Contractor's experience on similar projects.
- Market conditions.

Estimating a percent markup is more of an art than it is science and relies heavily on experience and the gut feeling of contractors. Many statistic-based models have been developed in the literature to support contractors' decision on bid/no-bid and markup estimation. The key to theses models is storing information related to past bids and analyzing the bidding behavior of competing companies. One approach is also to analyze the behavior of the lowest bidder in past bids. This analysis helps in determining an optimum markup value that makes the bid low enough to win the job, yet high enough to attain a fair profit.

Once a markup percentage is decided, the total of direct cost, indirect cost, and markup form the total bid price. This works fine for lump-sum contracts because the contractor is obliged to submit only one figure of his final bid. However, in unit price contracts, the contractor is required to submit unit prices associated with the bid items, which embed all the costs. While direct cost are estimated for each item independently, contractors need to distribute the total of the indirect cost plus markup among the items to determine the final unit prices. Generally, there are two ways by which the contractor can allocate the indirect cost and markup to the bid items. A straightforward method is to distribute these costs to all items according to their relative direct costs. This is known as "balanced bidding." Alternatively, a contractor can perform "unbalanced bidding" by raising the prices on certain bid items and decreasing the prices on others so that the total bid price remains the same. There are two main reasons for unbalancing:

1. Improving project financing; and
2. Adjusting the bid under expected quantity change.

To improve project financing, a contractor can raise the unit prices for the bid items that come early in the schedule and also reduce the prices for later items. This enables the contractor to charge more for early work and accordingly will receive a higher owner payment such that his own financing cost is less. Also, when the contractor knows by experience that the bid quantities are inaccurate, he or she can adjust his or her prices to attain a competitive edge and possibly a more potential profit. For example, when a certain item is expected to have much less quantity than stated in the bid package, the contractor may reduce the bid price on this item to produce a competitive bid, yet without much loss since the item is going to have less quantity than specified. Also, when the contractor expects that a certain item will increase in quantity, he or she may increase the unit price on such an item to increase his or her potential profit. In all cases, however, bid unbalancing is a risky task to the contractor. Some owners analyze the bids to detect bid unbalancing and disqualify the bidders who employ this approach.

5 Commercial Estimating Software

Computers have clearly added speed, power, and accuracy to construction cost estimation. A wide variety of software systems for estimation have been developed for commercial use (Table 3). Many of these systems also provide integration with various modules for quantity take off, scheduling, and CAD.

These software tools can organize the estimate, link it to resource databases, provide reports, and possibly integrate with other systems. In principal, they do the same functions as the Excel estimating system presented in this chapter. They, however, vary in their strengths and weaknesses. Also, in many situations, they involve a rigid structure that is different from what the user is familiar with. A thorough investigation of their capabilities is, therefore, highly recommended before purchasing software. Experimenting with a working demo version may be a good evaluation for the suitability of certain software to the requirements of the user. A good Internet search can also be helpful in this regard.

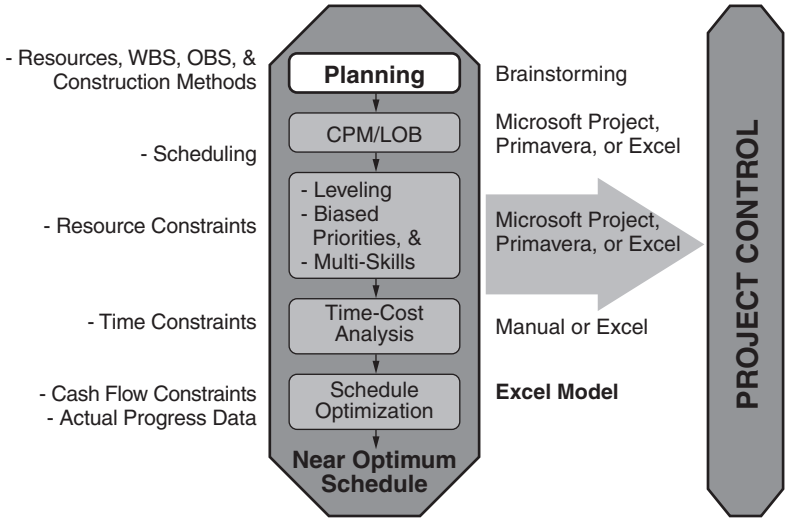
Table 3. Cost Estimation Software Systems

Computer Software	Description
Win Estimate	Building construction estimator assigns WBS tags to each item.
Success	Cost estimation and cost management with a link to scheduling software.
Design 4/Cost	Preliminary estimate based on square foot system.
Microfusion for Windows	An advanced integrated planning, estimating, proposal preparation, and performance management system.
Timberline	A cost estimating software with modules for CAD and scheduling.
G2 Estimator	Cost estimation based on previous experience.
Best Estimate	Cost estimation software.

6 Back to Our Case Study Project

In terms of the road map to our case study, the material in this chapter continues the planning (shaded box) by estimating the resources, durations, and costs of the activities' methods of construction.

Figure 13. Case Study Outline

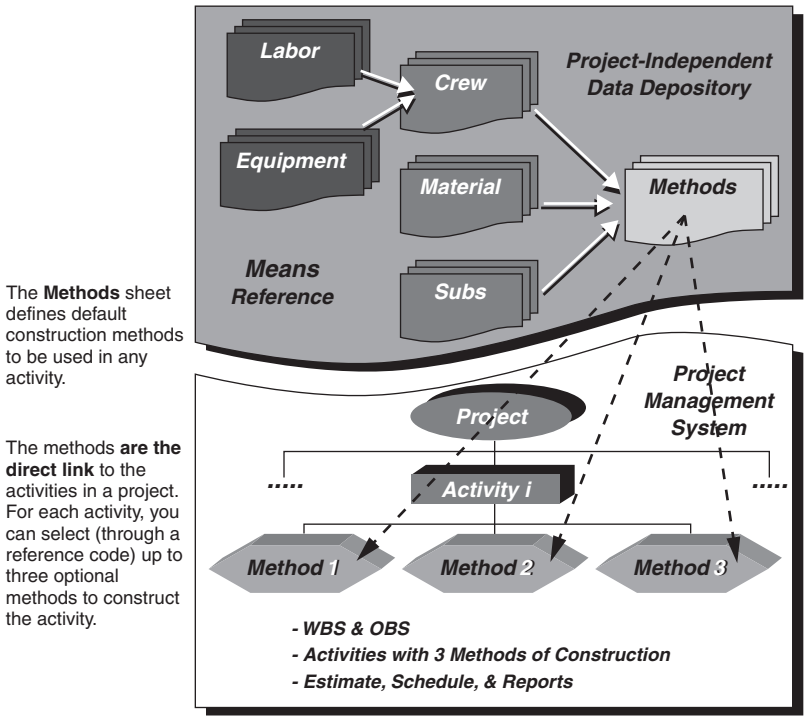


6.1 A Spreadsheet-Based System

With our knowledge of the basic equations for cost and time estimation, this section presents you with a simplified Excel system that uses the Excel functions. The system represents an integrated approach for planning, estimating, schedule optimization, and project control (see Figure 14). The whole system fits into a single Excel file **Case-Study.xls**. All the data in this file belong to our case study project but you can use the same file as a template for other projects. You can experiment with the various sheets of this Excel file and view the underlying formulas (shaded cells). The two main components of the system are:

a. a depository of project-independent data.
b. a project management system for estimating, scheduling, and project control.

Figure 14. Components of the Excel Project Management System



6.1.1 Data Depository The data depository of the system is needed to provide data for the project management system in a manner that reduces redundancy, saves time and cost, and increases productivity. Similar to the way we did in Example 2 before, the design of the data depository in Excel involved setting up several data lists, establishing relationships among them, and designing related reports. As shown in Figure 14, it incorporates the following six worksheets. A description is these sheets is provided next along with various screen shots:

- **5 Resource Sheets:** Labor, Equipment, Crews (combination of labor and equipment), Materials, and Subcontractors;
- **1 Construction Methods Sheet.**

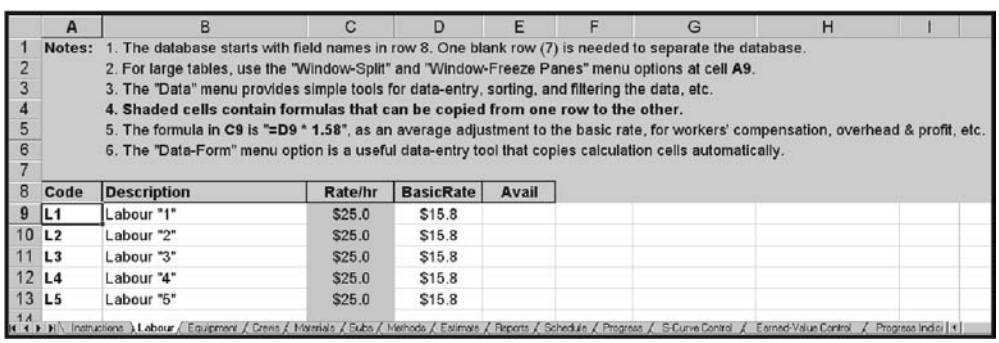
Labor: The *labor list* (Figure 15) contains five fields: code; description; total hourly rate (Rate/hr); basic hourly rate; And availability constraints (not used here). Basic rates are obtained by a means-based average of wage rates from 30 major U.S. cities. The total rate (rate/hr) is then calculated by multiplying the basic rate with a constant, 1.58, which is an average of the adjustments used by means to the basic rate for workers' compensation, overhead, and profit (O&P).

Equipment: The equipment basic rate (Figure 16) includes not only rental cost, but also operating costs such as fuel, oil, and routine maintenance. An average of 10% is added to the basic rate for O&P to calculate the rate/hr.

Crews: Crews were defined by assigning up to five labor and equipment resources, using their codes as reference (Figure 17). Accordingly, the calculations in columns N to R use the VLOOKUP function to determine the individual costs per day of the five resources. These costs are then summed in column C to determine the total crew rate per day, Rate/d.

Material: The material basic unit cost (Figure 18) includes delivery to the site, without including the sales tax or allowance for wasted material. An average 10% is added to the basic unit cost for O&P to calculate the Cost/Unit.

Figure 15. Labor Sheet

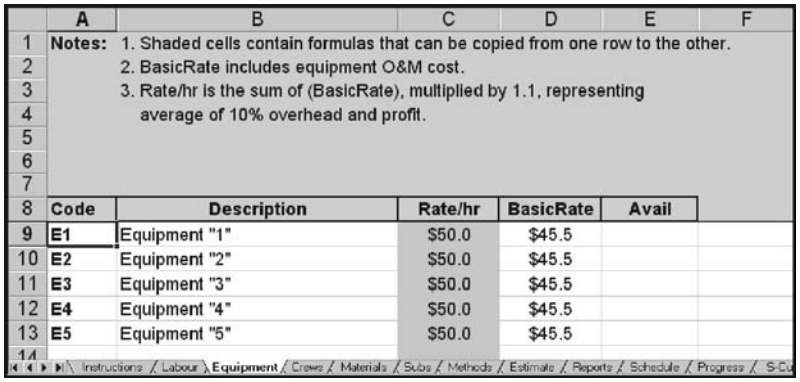


Notes:
1. The database starts with field names in row 8. One blank row (7) is needed to separate the database.
2. For large tables, use the "Window-Split" and "Window-Freeze Panes" menu options at cell **A9**.
3. The "Data" menu provides simple tools for data-entry, sorting, and filtering the data, etc.
4. **Shaded cells contain formulas that can be copied from one row to the other.**
5. The formula in **C9** is **"=D9 * 1.58"**, as an average adjustment to the basic rate, for workers' compensation, overhead & profit, etc.
6. The "Data-Form" menu option is a useful data-entry tool that copies calculation cells automatically.

Code	Description	Rate/hr	BasicRate	Avail
L1	Labour "1"	$25.0	$15.8	
L2	Labour "2"	$25.0	$15.8	
L3	Labour "3"	$25.0	$15.8	
L4	Labour "4"	$25.0	$15.8	
L5	Labour "5"	$25.0	$15.8	

Instructions / Labour / Equipment / Crews / Materials / Subs / Methods / Estimate / Reports / Schedule / Progress / S-Curve Control / Earned-Value Control / Progress Indic

Figure 16. Equipment Sheet



Notes:
1. Shaded cells contain formulas that can be copied from one row to the other.
2. BasicRate includes equipment O&M cost.
3. Rate/hr is the sum of (BasicRate), multiplied by 1.1, representing average of 10% overhead and profit.

Code	Description	Rate/hr	BasicRate	Avail
E1	Equipment "1"	$50.0	$45.5	
E2	Equipment "2"	$50.0	$45.5	
E3	Equipment "3"	$50.0	$45.5	
E4	Equipment "4"	$50.0	$45.5	
E5	Equipment "5"	$50.0	$45.5	

Instructions / Labour / Equipment / Crews / Materials / Subs / Methods / Estimate / Reports / Schedule / Progress / S-Cu

Figure 17. Crews Sheet

The easiest approach to add new crews is to copy the last row to a new one and then modify its data.

Notes: 1. A crew contains up to five labour and equipment resources;
2. Select LABOUR or EQUIPMENT using the comboboxes and then copy their codes from cells O2 or O3 to resource fields **Res1** to **Res5**; and
3. Shaded cells contain formulas that can be copied from one row to the other.

Selection: L5 / E1

Code	Description	Rate/d	NoR1	Res1	NoR2	Res2	NoR3	Res3	NoR4	Res4	NoR5	Res5	$Res1	$Res2	$Res3	$Res4	$Res5	Avail
CR-01	Crew "1"	$500	0.25	E1	2.00	L1							$12.5	$50.0				
CR-02	Crew "2"	$800	0.50	E2	0.50	E3	2.00	L1					$25.0	$25.0	$50.0			
CR-03	Crew "3"	$1,400	2.00	E1	2.00	L1	1.00	L4					$100.0	$50.0	$25.0			
CR-04	Crew "4"	$2,600	3.00	E2	3.00	L2	4.00	L1					$150.0	$75.0	$100.0			
CR-05	Crew "5"	$800	2.00	L1	2.00	L5							$50.0	$50.0				
CR-06	Crew "6"	$1,800	2.00	L1	2.50	E5	1.00	E3					$50.0	$125.0	$50.0			
CR-07	Crew "7"	$1,400	2.00	L1	1.00	L2	2.00	E5					$50.0	$25.0	$100.0			
CR-08	Crew "8"	$2,000	2.00	L1	1.00	L2	1.00	L3	3.00	E5			$50.0	$25.0	$25.0	$150.0		
CR-09	Crew "9"	$700	2.00	L1	0.50	L5	0.50	L4	0.25	E3			$50.0	$12.5	$12.5	$12.5		
CR-10	Crew "10"	$686	1.00	L2	2.00	L1	0.21	E4					$25.0	$50.0	$10.7			
CR-11	Crew "11"	$3,000	2.00	E1	3.00	E3	4.00	L1	1.00	L3			$100.0	$150.0	$100.0	$25.0		
CR-12	Crew "12"	$2,000	1.00	E2	2.00	E3	2.00	L1	2.00	L2			$50.0	$100.0	$50.0	$50.0		
CR-13	Crew "13"	$1,800	2.00	E1	4.00	L1	1.00	L4					$100.0	$100.0	$25.0			
CR-14	Crew "14"	$2,200	2.00	E2	3.00	L2	4.00	L1					$100.0	$75.0	$100.0			
CR-15	Crew "15"	$200	1.00	L1									$25.0					
CR-16	Crew "16"	$400	2.00	L1									$50.0					
CR-17	Crew "17"	$600	3.00	L1									$75.0					
CR-18	Crew "18"	$800	4.00	L1									$100.0					

Instructions / Labour / Equipment / Crews / Materials / Subs / Methods / Estimate / Reports / Schedule / Progress / S-Curve Control / Earned-Value Control / Progress Indic

Figure 18. Materials Sheet

Notes: 1. The "Avail" field can be used to link this table to other inventory sheets.
2. An average 10% is added to the Basic$/Unit for overhead and profit.
3. Material costs include delivery to the site. No sales tax included or allowance for wasted material.

Code	Description	Cost/Unit	Basic$/Unit	Unit	Avail
M1	Material "1"	$100.0	$90.9	unit	
M2	Material "2"	$100.0	$90.9	unit	
M3	Material "3"	$100.0	$90.9	unit	
M4	Material "4"	$100.0	$90.9	unit	
M5	Material "5"	$100.0	$90.9	unit	

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Subcontractors: The subs sheet (Figure 19) defines various subcontractors, providing their unit cost (SubCost) for the required tasks. An average of 10% is added to the SubCost for O&P to calculate the Cost/Unit.

Methods of Construction: Various methods of construction were defined in a separate worksheet, Methods, following the R.S. Means approach (Figure 20) so that they become ready for use in any project estimate. The Methods sheet defines the resources used in each construction method (crews and material, or subcontractor), the overtime strategy they use, daily production rate, and assumed seasonal productivity factors. To facilitate user input of the resources used in each method, some screen elements such as combo boxes are used on the sheet, as shown in Figure 20. The same coding system of the means can be used in this worksheet. The regular daily production rate **RegPr/d** is obtained directly from the means or input by the user according to experience and/or company records.

Three seasonal productivity rates (winter, spring, and fall) can be specified to each method. These factors adjust the daily production rates, depending on the season in which the activity planned to be constructed. For activities that are insensitive to weather conditions, the user can use a value of 1.0 for the three factors. It is noted that the use of these factors becomes advantageous when the estimate is integrated with a scheduling module. These factors, as such, make it possible to refine the cost based on the scheduled time of the activities.

Figure 19. Subcontractors Sheet

The lump sum values can be quoted directly from local subcontractors.

Notes: 1. An average 10% is added to the SubCost for overhead and profit.

Code	Description	Cost/Unit	Sub-Contractor	SubCost/Unit	Unit
S1	Type of Work 1	$4,000.7	Sub-contractor "1"	$3,637.0	LSUM
S2	Type of Work 2	$3,601.0	Sub-contractor "2"	$3,273.6	LSUM
S3	Type of Work 3	$21.3	Sub-contractor "3"	$19.4	LSUM
S4	Type of Work 4	$5,601.3	Sub-contractor "4"	$5,092.1	LSUM
S5	Type of Work 5	$20.0	Sub-contractor "5"	$18.2	LSUM
S6	Type of Work 6	$12,800.6	Sub-contractor "6"	$11,636.9	LSUM
S7	Type of Work 7	$12,600.6	Sub-contractor "7"	$11,455.1	LSUM
S8	Type of Work 8	$15,800.2	Sub-contractor "8"	$14,363.8	LSUM
S9	Type of Work 9	$7,600.4	Sub-contractor "9"	$6,909.5	LSUM

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Notes:
1. Select a CREW (or a SUB) and a MATERIAL using the comboboxes, then copy their code from cells J2, J3, & J4 to fields **Crew/SUB/Material**.
2. Shaded cells contain formulas that can be copied from one row to the other.
3. **Assumptions**: Week is 5days, 8hours Overtime hour is 90% productivity; and First 4 overtime hours, rate is 1.2 of normal rate, afterwards, 1.5 times.

Selection: CR-03 Crew; M2 Material; S2 Sub

Code	Description	Cost /d	TotPr /d	Unit Cost	Units	Crew	Sub	RegPr/d	MatQ/d	Material	Hrs/d	OTadj	MatCost	CrewCost	SubCost	WinProd	SprProd	FallProd
CSI-01-1	Md 1	$500	100.00	$5	unit	CR-01		100.000			8.00	8.00		499.93		1.00	1.00	1.00
CSI-01-2	Md 2	$1,667	100.00	$17	unit	CR-02		100.000	8.67	M2	8.00	8.00	866.67	799.93		1.00	1.00	1.00
CSI-01-3	Md 3	$3,000	150.00	$20	unit	CR-03		122.450	11.90	M3	10.00	10.40	1,190.16	1,819.86		1.00	1.00	1.00
CSI-02-1	Md 4	$5,533	200.00	$28	unit	CR-18	S3	200.000	4.73	M1	8.00	8.00	472.66	799.86	4,260.81	1.00	1.00	1.00
CSI-02-2	Md 5	$2,000	125.00	$16	unit	CR-05		125.000	12.00	M1	8.00	8.00	1,200.00	799.86		1.00	1.00	1.00
CSI-02-3	Md 6	$2,250	175.00	$13	unit	CR-06		175.000	4.50	M1	8.00	8.00	450.07	1,799.93		1.00	1.00	1.00
CSI-03-1	Md 7	$5,000	125.00	$40	unit	CR-07		125.000	36.00	M2	8.00	8.00	3,600.11	1,399.89		1.00	1.00	1.00
CSI-03-2	Md 8	$1,500	5.00	$300	unit	CR-16	S5	5.000	10.00	M3	8.00	8.00	1,000.00	399.93	100.07	1.00	1.00	1.00
CSI-04-1	Md 9	$750	0.06	$12,000	unit	CR-09		0.063	0.50	M4	8.00	8.00	50.00	700.01		1.00	1.00	1.00
CSI-04-2	Md 10	$886	0.07	$12,400	unit	CR-10		0.071	2.00	M4	8.00	8.00	199.97	685.75		1.00	1.00	1.00
CSI-05-1	Md 11	$1,067	0.08	$12,800	unit	CR-17	S4	0.083			8.00	8.00		599.89	466.77	1.00	1.00	1.00
CSI-06-1	Md 12	$2,000	0.13	$16,000	unit	CR-16	S6	0.125			8.00	8.00		399.93	1,600.07	1.00	1.00	1.00
CSI-06-2	Md 13	$2,700	0.17	$16,200	unit	CR-17	S7	0.167			8.00	8.00		599.89	2,100.11	1.00	1.00	1.00
CSI-07-1	Md 14	$8,500	0.50	$17,000	unit	CR-17	S8	0.500			8.00	8.00		599.89	7,900.11	1.00	1.00	1.00
CSI-07-2	Md 15	$1,667	0.17	$10,000	unit	CR-16	S9	0.167			8.00	8.00		399.93	1,266.74	1.00	1.00	1.00
CSI-08-1	Md 16	$1,667	0.17	$10,000	unit	CR-16	S1	0.167	6.00	M6	8.00	8.00	599.95	399.93	666.78	1.00	1.00	1.00
CSI-08-2	Md 17	$800	0.10	$8,000	unit	CR-16	S1	0.100			8.00	8.00		399.93	400.07	1.00	1.00	1.00
CSI-08-3	Md 18	$1,000	0.11	$9,000	unit	CR-17	S2	0.111			8.00	8.00		599.89	400.11	1.00	1.00	1.00

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Figure 20. Construction Methods Sheet

When the user specifies working hours per day (**hrs/d** field) that are greater than 8, the total daily production, **TotPr/d,** and the total daily cost, **Cost/d,** are automatically adjusted for the overtime. The assumptions made are as follows:

- Normal working hours are 8 hours/day.
- Overtime hour has 90% productivity of a regular hour.
- The hourly rate of the first 4 overtime hours is 1.2 the normal hourly rate, Afterwards it is 1.5 of the normal hourly rate.
- Two methods can be identical except work hours are different.

It is noted that the methods that involve subcontractors may need special care. As shown, the regular production rate, **RegPr/d,** is a fraction that is determined based on the duration quoted for the job. For example, if the subcontractor is doing a lump sum job (i.e., quantity = 1) that takes him 10 days to finish, then his production should be 1/10 or 0.1 units per day. Here, Regular Production = 1 / Duration.

6.1.2 Project Management System Added to the six worksheets of the data depository, the **Case-Study.xls** file incorporates various other sheets that form a comprehensive system for estimating, schedule optimization, and project control. The latter sheets relate to the specific project being analyzed. The first sheet that needs to be set up is the Estimate sheet. This sheet, in addition to the Reports sheet, are described in this chapter.