THE MANAGEMENT OF CONTINGENCY AND ESCALATION IN CONSTRUCTION

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ABSTRACT

THE MANAGEMENT OF CONTINGENCY AND

ESCALATION IN CONSTRUCTION

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The objectives of this major technical report are; to describe clearly the notions of contingency and escalation as seen through the eyes of owners and engineering project managers; to identify the significance of contingency and escalation in the different phases of the project development life cycle; to describe how contingency and escalation are incorporated into the cost control program for a construction project; and to identify areas where further work should be directed.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Over the last few years, particularly since 1973 when the oil embargo fostered a spectacular rise in fuel costs, material and labour costs have been increasing annually to the extent that careful methods must now be used to carry out cost forecasts and estimates on large scale projects. The design and construction of large scale projects (projects in the million and multi-million dollar range) require the expenditure of money over a period of several years and warrant careful cash flow management and scheduling. These projects may involve complex technology (which in some cases may be unproven), and innovations in construction technology. Thus a project may be comprised of many uncertainties that necessitate some type of risk evaluation with respect to cost. These projects generate very high carrying charges, especially with the high interest rates that are prevalent today. As well, ever rising construction costs make it difficult to predict costs for a project of long duration.

Tables 1-1 and 1-2 serve to illustrate the rise of construction wage indices and construction project cost indices. Table 1-1 shows the construction workers' wage indices for 1977 and 1978. Notice that with few exceptions, wages increased from 1977 to 1978. The base index in all cities for all trades was 100 in 1967. Careful observation of the table will indicate that wages have increased substantially since 1967, clearly demonstrating the effect of high annual inflation rates.

TABLE 1-1

Construction Workers' Wage Indices

	Common Labour			Skilled Labour			Electrician			Equipment Operator			Mechanical Trades		
	77	78	% chg	77	78	% chg	77	78	% chg	77	78	% chg	77	78	% chg
Atlanta	243	259	+6.6	214	224	+4.7	243	251	+3.3	224	251	+12.1	230	236	+2.6
Baltimore	285	285	-	228	237	+3.9	231	254	+10.0	224	232	+3.6	235	239	+1.7
Birmingham	260	278	+6.9	229	251	+9.6	249	265	+6.4	234	262	+12.0	247	261	+5.7
Boston	235	251	+6.8	222	236	+6.3	223	241	+8.1	231	243	+5.2	236	247	+4.7
Chicago	235	250	+6.4	227	239	+5.3	248	264	+6.5	236	258	+9.3	235	246	+4.7
Cincinnati	269	288	+7.1	251	268	+6.8	230	245	+6.5	264	281	+6.4	263	283	+7.6
Cleveland	246	264	+7.3	237	252	+6.3	244	250	+2.5	240	253	+5.4	238	252	+5.9
Dallas	260	260	-	226	245	+8.4	235	260	+10.6	323	353	+9.3	242	244	+0.1
Denver	248	266	+7.3	243	252	+3.7	262	267	+1.9	244	280	+14.8	247	262	+6.1
Detroit	246	263	+6.9	241	264	+9.5	243	260	+7.0	252	269	+6.7	235	269	+14.5
Kansas City	289	303	+4.8	254	271	+6.7	259	259	-	294	313	+6.5	241	286	+18.7
Los Angeles	269	288	+7.1	262	280	+6.9	270	284	+5.2	251	268	+6.8	238	255	+7.1
Minneapolis	236	251	+6.4	230	245	+6.5	244	260	+6.6	236	250	+5.9	234	251	+7.3
New Orleans	269	291	+8.2	239	255	+6.7	234	241	+3.0	235	241	+2.6	235	249	+6.0
New York	212	229	+8.0	217	216	-0.5	243	262	+7.8	207	238	+15.0	243	261	+7.4
Philadelphia	270	283	+4.8	238	248	+4.2	253	262	+3.6	235	244	+3.8	235	243	+3.4
Pittsburgh	247	268	+8.5	225	236	+4.9	198	212	+7.1	240	255	+6.3	228	239	+4.8
St. Louis	244	255	+4.5	213	228	+7.0	221	240	+8.6	225	248	+10.2	216	219	+1.4
San Francisco	250	270	+8.0	235	259	+10.2	247	289	+17.0	236	275	+16.5	235	252	+7.2
Seattle	253	277	+9.5	238	264	+10.9	290	303	+4.5	230	250	+8.7	287	312	+8.7

* Official ENR December indices including base wages and fringes; base: 1967 = 100

Source: Engineering News Record, December 21, 1978

Table 1-2 contains an index of construction costs for various large scale project items and activities. The increasing costs have been recorded from 1972 to 1978 for each entry and indicate that costs have increased from 65 to 90 percent over 1972 costs. These tables demonstrate the order of magnitude of cost increases for material and labour and place in perspective the need for careful planning and management of project costs when the construction industry is faced with inflation.

The effects of tight money, foreign exchange, uncertain technology, high interest rates and inflation on capital construction projects are likely to remain serious in the years ahead. Thus in order to estimate the costs of large and complex construction projects to a reasonable degree of accuracy, it has become necessary to utilize available methods to account for these previously mentioned effects.

Various methods to improve the accuracy of cost estimates have been used for many years but recently more emphasis has been put into determining ways and means of forecasting cost increases and allowances for uncertainties to account for the relentlessly increasing inflationary spiral. Methods for predicting and managing escalation and contingency and how they relate to construction form the focus of this paper.

The objectives of this report are:

TABLE 1-2

U.S. Bureau of Reclamation Construction Costs

	October 1972	1973	1974	1975	1976	1977	1978	% chg. 7/78 10/78	% chg. 10/77 10/78
COMPOSITE INDEX	1.40	1.49	1.78	1.97	2.08	2.20	2.36	+1.7	+7.3
DAMS									
Earth	1.41	1.49	1.78	1.97	2.05	2.13	2.24	+1.4	+5.2
Structures	1.35	1.43	1.69	1.90	1.96	2.04	2.13	+0.9	+4.4
Spillway	1.44	1.53	1.85	2.03	2.10	2.18	2.31	+2.2	+6.0
Outlet works	1.52	1.61	1.93	2.09	2.18	2.29	2.45	+2.1	+7.0
Concrete	1.37	1.46	1.74	1.94	2.04	2.16	2.32	+2.2	+7.4
Diversion	1.38	1.45	1.77	1.95	2.06	2.18	2.33	+1.3	+6.9
PUMPING PLANTS									
Building and equipment	1.40	1.48	1.78	1.98	2.09	2.24	2.41	+1.7	+7.6
Structure, reinforcement concrete & improvements	1.32	1.39	1.74	1.93	2.03	2.16	2.32	+1.[illegible]	+7.4
Equipment	1.53	1.61	1.86	2.07	2.20	2.36	2.55	+1.2	+8.1
pumps & prime equipment	1.52	1.60	1.87	2.13	2.27	2.45	2.67	+1.5	+9.0
accessory electrical & miscellaneous equipment	1.55	1.63	1.86	2.01	2.12	2.24	2.39	+0.8	+6.7
STEEL PENSTOCKS, DISCHARGE PIPES	1.49	1.58	1.88	2.02	2.15	2.29	2.51	+1.2	+9.9
CANALS	1.36	1.44	1.76	1.99	2.07	2.18	2.31	+1.8	+6.0
Earthwork	1.41	1.48	1.75	2.01	2.07	2.17	2.29	+1.8	+5.5
Structures	1.33	1.41	1.76	1.96	2.06	2.19	2.35	+2.2	+7.3
CONDUITS (tunnels, concrete-lined)	1.35	1.45	1.76	1.94	2.05	2.18	2.35	+1.7	+7.8
LATERALS AND DRAINS	1.33	1.40	1.72	1.91	1.99	2.06	2.1[illegible]	+1.4	+5.3
Earthwork	1.39	1.45	1.69	1.92	1.99	2.05	2.13	+0.9	+3.9
Structures	1.29	1.39	1.74	1.90	2.00	2.08	2.20	+1.4	+5.8
POWER PLANTS, HYDRO									
Building and equipment	1.41	1.47	1.75	1.97	2.08	2.21	2.36	+1.3	+6.8
Structure, reinforcement concrete & improvements	1.32	1.40	1.75	1.94	2.04	2.17	2.33	+2.2	+7.4
Equipment	1.46	1.53	1.75	1.98	2.11	2.25	2.40	+1.3	+6.7
turbine and generators	1.48	1.54	1.75	2.00	2.12	2.26	2.41	+1.3	+6.6
accessory electrical & miscellaneous equipment	1.45	1.53	1.77	1.95	2.06	2.18	2.34	+1.3	+7.3
PIPELINE, concrete	1.31	1.39	1.66	1.88	1.96	2.02	2.22	+2.3	+9.9
SWITCHYARDS & SUBSTATIONS	1.38	1.44	1.74	1.91	2.01	2.13	2.28	+1.3	+7.0
TRANSMISSION LINES									
Wood poles, 115 kV	1.40	1.54	1.89	1.96	2.09	2.33	2.52	+1.2	+8.2
poles and fixtures	1.51	1.74	2.12	2.16	2.31	2.58	2.82	+1.8	+9.3
conductors, devices	1.32	1.36	1.66	1.78	1.88	2.09	2.24	+0.9	+7.2
Steel tower, 230 kV	1.39	1.45	1.82	1.98	2.08	2.25	2.48	+1.6	+8.8
GENERAL PROPERTY - BUILDINGS	1.48	1.61	1.89	2.00	2.12	2.28	2.49	+1.6	+9.2
ROADS, primary	1.34	1.42	1.79	1.99	2.09	2.22	2.39	+1.7	+7.7
secondary	1.33	1.40	1.71	1.94	2.02	2.11	2.32	+2.7	+10.0
BRIDGES, steel	1.41	1.48	1.77	1.99	2.11	2.23	2.42	+2.1	+8.5

SOURCE: U.S. Bureau of Reclamation, Denver, Colo. Base: 1967 = 1.0.

* Project cost to federal government of BuRec projects in 18 western states including Alaska.

SOURCE: Engineering News Record, December 21, 1978.

(1) To describe clearly the notions of escalation and contingency and the significance of their roles in the different phases of the project development life cycle;

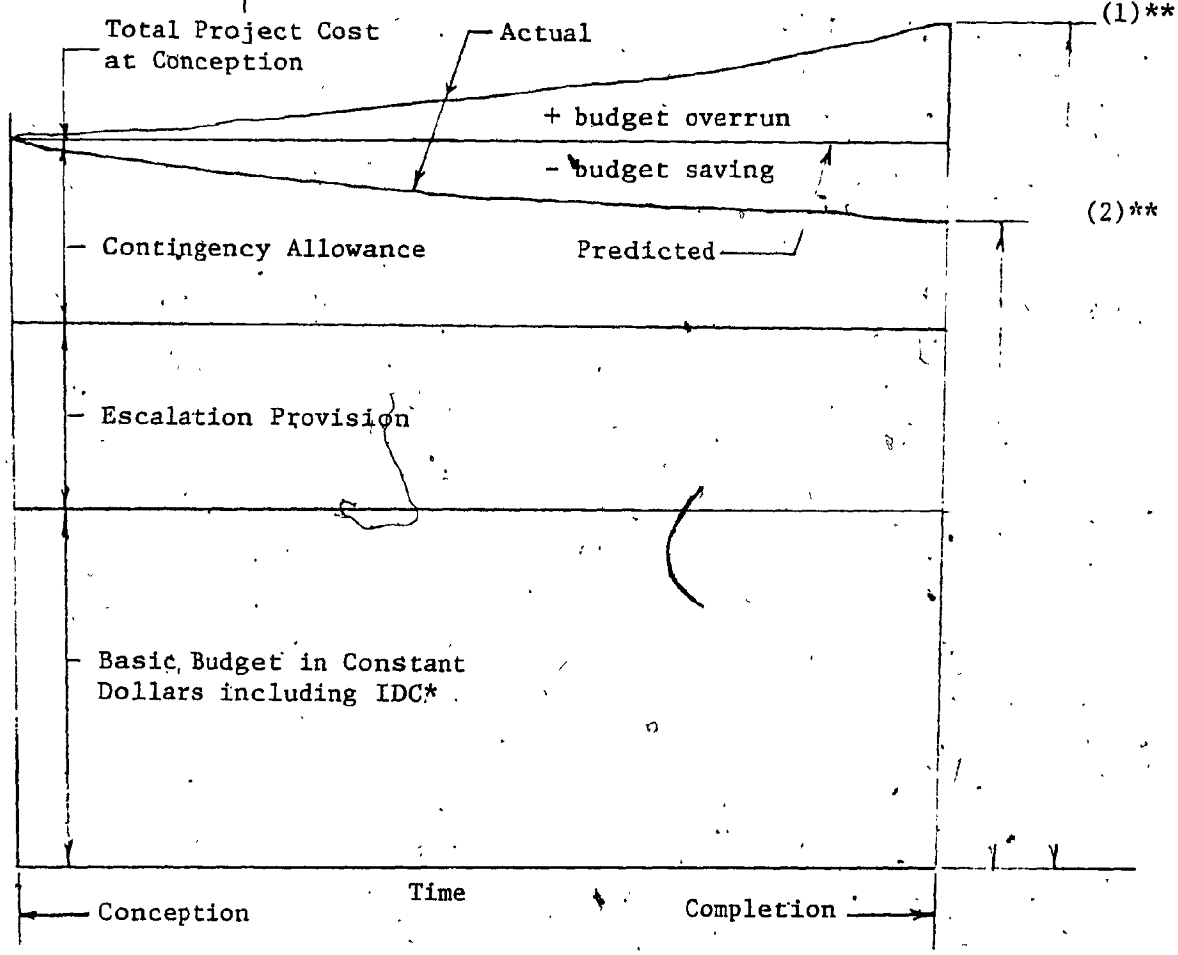
(2) To describe the state of the art with respect to how escalation and contingency are estimated, how they are incorporated into the cost control program for a project, and how they can be managed;

(3) To identify the areas where further research work should be directed.

The point of view expressed throughout this paper shall be that of the project manager and his staff who, as a group, represent the owner and his interests. Thus this report should be of interest to owners and project managers employed by integrated engineering firms.

Escalation can be defined as a dollar allowance to provide for future increases in costs (for materials and labour) that are likely to occur due to the difference in time between design of a project and the procurement or construction of its components.

Contingency is the specific provision for unforeseeable elements or uncertainties of cost within the defined project scope. Changes in scope are not addressed and a change of scope would result in a change in the basic budget.



* IDC - interest during construction

** 1 or 2 denote the project cost at completion

Figure 1-1: Components of total project cost

Most projects require several years from the initial conception, through design and construction to completion. By referring to Figure 1-1, which shows the estimated total capital cost at conception and two possible total costs at completion along with the initial escalation provision and contingency allowance, it becomes clear that contingency and escalation amount to a substantial portion of the total project cost at conception and must be accounted for in as precise a manner as possible. In particular, the final cost at completion may come over as denoted by 1, or under as denoted by 2, the original capital cost as shown at the right of Figure 1-1. Should the final cost be over the original estimate, (assuming that the basic budget was estimated correctly) then the initial escalation provision and/or contingency allowance as applied were inadequate and conversely if the final cost was less than the original cost, then the project had too high a contingency allowance and/or escalation provision. Obviously, the second case would be preferable to the project manager, as an overall project cost saving would be realized.

Contingency shall be dealt with in detail in Chapter 2 and Escalation shall be similarly treated in Chapter 3.

Chapter 4 will contain a sample calculation incorporating both contingency and escalation into a cost budget.

Chapter 5 will discuss recommendations for further research and outline the conclusions of the paper.

CHAPTER 2

CONTINGENCY

2.1 INTRODUCTION

Contingency is defined by Webster's dictionary as "that which is likely, but not certain to happen; possible happenings by chance or unforeseen causes".

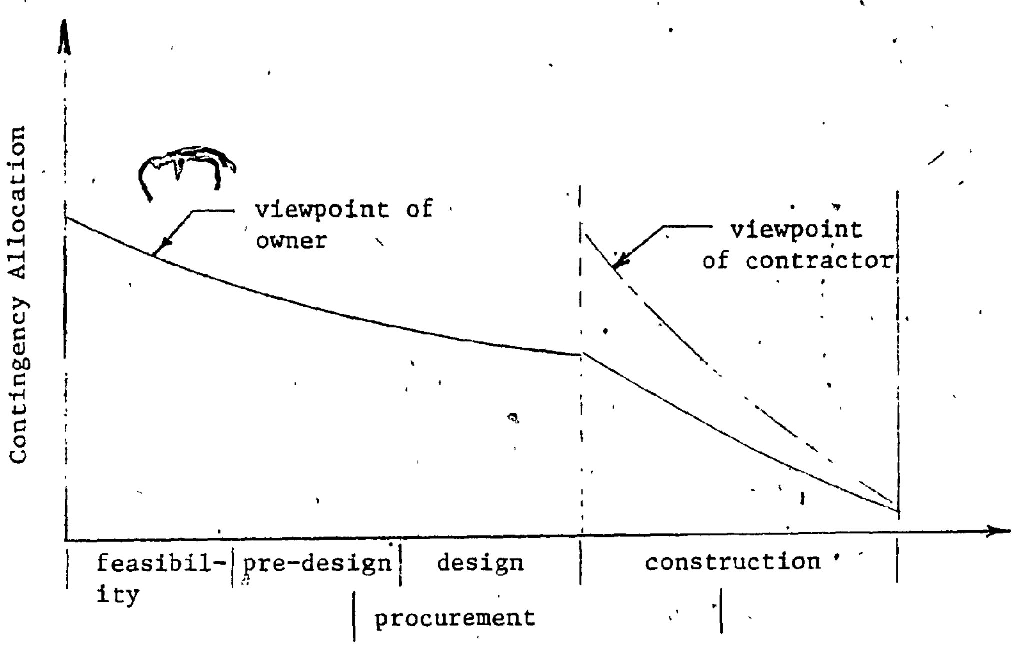
The American Association of Cost Engineers defines contingency as the "specific provision for unforeseeable elements of cost within the defined project scope; particularly important where previous experience relating estimates and actual costs has shown that, statistically, unforeseeable events which will increase costs are likely to occur".(35)

For the purposes of this paper, this definition shall be further clarified by emphasizing that contingency is an allowance for uncertainties, unforeseens, intangibles and minor omissions or errors. It is never an allowance for changes that have already occurred and is not intended to cover changes in the project scope (i.e. changes in owner philosophy, revisions to basic designs and process systems). A contingency allowance is only included for normal estimate uncertainties. An estimate that is extremely conceptual and based upon little or no actual design information has a large possible cost variance and should include an appropriately high contingency allowance. On the other hand, if no uncertainty exists with regard to a particular segment of the estimate, no contingency should be included.

It must be pointed out that this paper assumes the viewpoint of the project manager and his staff as representatives of the owner. The viewpoint for contingency across a project life cycle is different for the owner and the contractor. These two viewpoints are depicted in Figure 2-1.

FIGURE 2-1

Project Life Cycle and Contingency



The owner allots funds to contingency at the start of the project and expects these funds to deplete to zero or remain in reserve by the completion date. The contractor who comes in at the beginning of the construction stage assigns his own contingencies which may be higher or lower than the contingency allowed by the owner for this stage.

The essential difference between the owner's viewpoint and the contractor's viewpoint on contingency may be summed up as follows:

Owner/Consultant:

1. Designer: The designer may consider contingency as an extra fund from which coverage can be obtained for underestimated and omitted items.

2. Estimator: The estimator may consider contingency as a fund that is capable of covering the lack of definition, lack of experience in estimating for the project or activity type, and the multitude of other items connected with cost estimating.

3. Management: Management may view contingency as money that will not be spent and will become profit. However, management assumes ultimate responsibility for allocation of contingency if a consensus is not reached between the designer and estimator.

Contractor:

The Contractor should view contingency as a fund that must be accurately allocated to cover for lack of experience, lack of definition and lack of contractual agreement in order to allow him to bid successfully against others, while at the same time giving him a reasonable chance to assume at least a break-even conclusion to a project.

In the remainder of this Chapter we will discuss contingency, the uncertainties involved, types of contingency, cost reports and contingency, contingency depletion and appropriation, contingency and contracts and methods of calculating contingency.

2.2 UNCERTAINTY

Large construction projects that are currently being built, designed or still in the discussion stage involve a large degree of uncertainty with respect to such items as cost, time, energy supply, labour availability and productivity, market trends, estimating capability and management control.

The appraisal of such projects involves an evaluation of how certain events interact to produce a final outcome. The formulation of an estimate consists essentially of identifying the events most relevant to the final outcome of a given course of action and the corresponding costs that are reflected by this outcome.

From the owner's point of view, uncertainty may be reflected in one or any combination of the following considerations:

(1) Market trends;

(2) Material; equipment and labour shortages;

(3) Labour productivity;

(4) Escalation due to aspects of inflation;

(5) Political stability in foreign countries;

(6) Estimating omissions;

(7) Errors in base costs estimated (costs supplied by others);

(8) Changes in design due to engineering refinement;

(9) Changes in interest rates.

As was mentioned in the introduction, some aspects of contingency are viewed differently by owners and contractors. However, contingency is an essential element in project estimating and must not be omitted, neglected or most important of all - misunderstood.

2.3 CONTINGENCY - GENERAL

231 INTRODUCTION

The contingency allocated to a project cost estimate does not provide protection against costs incurred by scope changes unless a special built-in amount is specifically set aside for this possibility.

Some of the conditions that may occur during a project life cycle that are not accounted for in the estimate by the estimator acting on behalf of the owner are as follows:

(1) Change in concept (such as mat versus piles);

(2) New licensing, environmental or safety requirements;

(3) Site conditions other than those assumed;

(4) Accidents, catastrophies;

(5) Force majeure (conditions beyond contractor's control);

(6) New work rules (Union or Government);

(7) Strikes-abnormal (those that affect schedule);

(8) Weather (abnormal);

(9) Changes in work week from that anticipated;

(10) Changes in schedule due to items (7) and (8);

(11) Changes in tax rates.

Should any of the above occur during the project life cycle, adjustments would have to be made to the satisfaction of all parties regardless of the contract type.

Most projects, however, do have areas of concern such that a contingency appropriation is necessary to cover for uncertainties. Table 2-1 denotes five particular areas of concern during estimating, what the concern stems from and a practical example of what the corresponding contingency allocation must cover. These five areas come under either process design, detailed system design or market trends as described in Section 232.

The usual practice in contingency appropriation is to first examine the individual categories in the estimate. By doing this, the estimator attempts to assess, by some means or other, the degree of uncertainty surrounding each element or activity. When this degree has been established within a reasonable range, a realistic percentage to cover contingency is applied to the specific item. The total contingency then becomes the sum of the individual contingencies (should contingency be calculated in this manner).

232 TYPES OF CONTINGENCY

For the purposes of this paper, contingency is grouped under three separate headings as follows:

(1) Contingency on Process and Technology Design

Process design can be defined as a package system considered as an entity in itself (such as a boiler, turbine or pump). For the case of proven designs, the amount of contingency to cover uncertainty will be small or negligible, generally in the order of 0-3%[2]. However, if the designer is less familiar with the process, the contingency could be as high as 15%[2]. In the event that a design is unproven, the contingency could approach 100%[2].

TABLE 2-1

Estimation and Allocation of Contingency

Changes in:	Resulting from:	Example
(1) Quantities - Actual quantities greater than estimated.	Drawings, at time of estimate preparation, being sketchy, incomplete or unavailable.	No structural steel drawings have been made. Estimator, using the general arrangement drawings and his judgement arrives at 2000 tons of steel. Actual quantity installed, for same arrangement of plant, is 2200 tons. The 200 additional tons are a quantity variance.
(2) Design - Increased sizes or changes in specifications.	Development of engineering design.	A 12-inch diameter pipe system is changes to a 14-inch system or a 24-inch-thick concrete wall becomes 30 inches thick.
(3) Costs - Actual "initial" cost of material, equipment subcontracts, wages and/or fringe benefits greater than estimated.	Use of obsolete cost or recent "jump" in market cost.	Note: Variances due to cost or wage escalation are not considered here, but are covered under Item (4).
(4) Escalation - Actual price escalation of materials, equipment and/or craft wage escalation greater than assumed for estimate.	A greater rate of inflation.	Material and equipment prices and wages, based on historical trends and forecasted economic conditions, expected to increase at an average rate of 6% per year for material and equipment and 8% per year for craft wages. Actual increases amount to 8% and 9%, respectively.
(5) Labour Productivity Actual productivity poorer than that used in estimate.	Such things as a shortage of experienced and/or efficient craft workers and unusual working conditions.	Installation of cable trays taking 1.5 workhours per linear foot rather than the 1.0 workhour per foot estimated.

(2) Contingency on Detailed System Design

Generally the specific requirements for these systems are set out by a code or codes. The more that is known, the smaller the factor of ignorance required. There are no set rule of thumb percentages to apply to these elements, which comprise civil and non-process design. The experience of the designer and estimator together should be the necessary ingredients to ascertain an appropriate contingency allocation. Detailed system design could be defined as the design required to integrate two or more process design packages to achieve a workable system.

(3) Contingency to Account for Market Trends

This is the most important contingency allowance to be considered. This type requires much judgement and foresight along with a wealth of learned experience. Many factors are obviously affected by market trends and any shift in the norm will upset an estimate if the items affected have not been analyzed for uncertainty. From the owner's viewpoint some of these factors are as follows:

(a) Competitiveness - will the bidders for this type of contract be busy or idle?

(b) Commodity Prices - how do these prices fluctuate over a period of time compared to what they were when the estimate was made. Foreign exchange fluctuation may have to be considered.

(c) Productivity - what will bidders use relative to assumptions taken and what will be the effect of new labour agreements. If unemployment is low or high during the construction phase; how will this affect productivity?

(d) Escalation - what will the going escalation rates be during the construction phase, how does one account for a change in the forecast and actual escalation used and what are the contract clauses regarding escalation?

(e) Interest Rates - how to account for changes in forecast and actual interest rates.

Table 2-2 shows the phases in a project life cycle and the types of expected contingency for each phase. The degree of uncertainty decreases as the project proceeds. However, one observes that for process and technology design contingency, the uncertainty is virtually eliminated at the procurement stage (barring some scope change). Similarly, detailed system design (which compromises the civil, structural, electrical, and other systems) varies from a high contingency at feasibility to near zero contingency at the design development stage. The near zero terminology is used because minor design changes could occur due to unforeseeable problems during the construction stage. Therefore some degree of contingency should be allocated at the construction phase.

TABLE 2-2

Table Showing Applicable Contingency Types to Project Life Cycle Phases

Phase	Types of Contingency			UNCERTAINTY
	Process Design	Detailed Design	Market Trends	decreases increases
Feasibility	X	X	X	
Programming	X	X	X	
Conceptual Design	X	X	X	
Design Development	X	X	X	
Procurement	X		X	
Construction		X	X	
Commissioning			X	

With respect to market trends, the uncertainty decreases with project development. Definitely, there is a high degree of uncertainty at the feasibility phase concerning virtually every aspect of the planned project. The uncertainty varies little until the procurement stage. Through this phase and the next two, construction and commissioning, market trends play a major role in the contingency appropriation. Productivity, escalation and interest rates could be expected to vary from the predicted figures and therefore proper contingency monitoring should be mandatory to review and effectively manage these changes to avoid mis-allocation of the contingency funds.

233 CONTINGENCY ALLOCATIONS BASED ON EXPERIENCE

Through years of experience in evaluating and monitoring costs on large construction projects, many engineering firms have come up with percentages that apply to particular circumstances for contingency. The following figures proposed by Zeanah were applicable in 1973 but may be somewhat on the low side in 1979.

The following percentages have been selected as being representative for the purposes of this paper:[1]

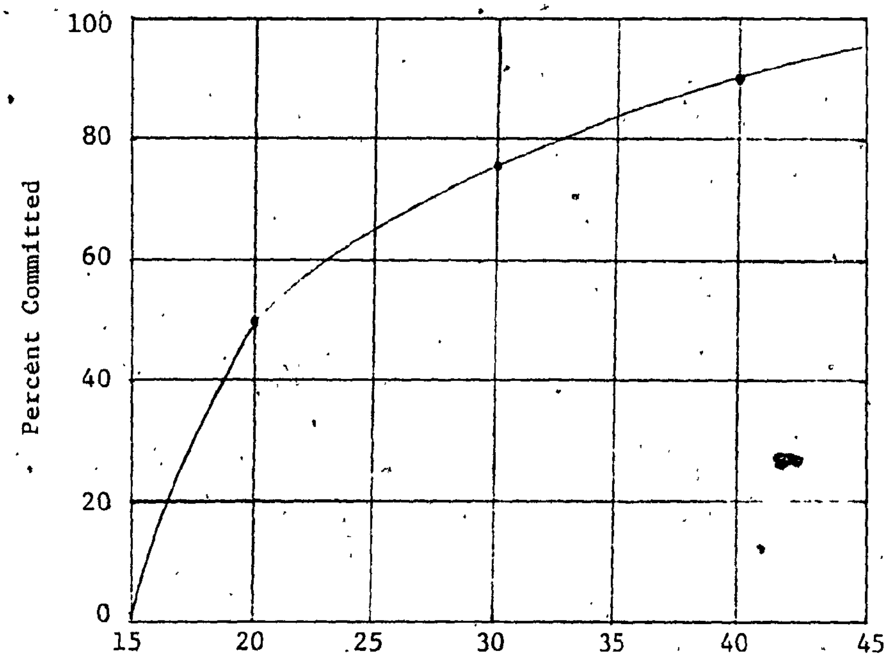
Good engineering definition and purchase order data	.... add 5%
Good engineering definition and no purchase order data	.... add 10%
Conception engineering - no purchase order data	.... add 20% to 30%

It should be noted that large unique projects like the Alaska pipeline, for which little or no past experience data on contingency were available, experienced contingencies much higher than the above.

The following two Figures, 2-2 and 2-3, depict the relationship between the committed amount for each segment of the project and the contingency allowance for the remaining uncommitted items (i.e. those still in the estimated category). As shown on Figure 2-2, at the project's inception when no monies are committed, the contingency allowance is 15 percent for the remaining uncommitted items. Since all items are uncommitted, the overall contingency is also 15 percent. At 50 percent committed, the total contingency becomes 12.5 percent.

FIGURE 2-2

Contingency Analysis Curve for Equipment



Percent Contingency on Uncommitted Items (1)

(1) Assume constant 5% contingency on Committed items

A. At 0% committed: Total Contingency = 15%

B. At 50% committed:

contingency on committed = (.05)(.5) = 2.5%
contingency on uncommitted = (.20)(.5) = 10.0% = 12.5%

C. At 90% committed:

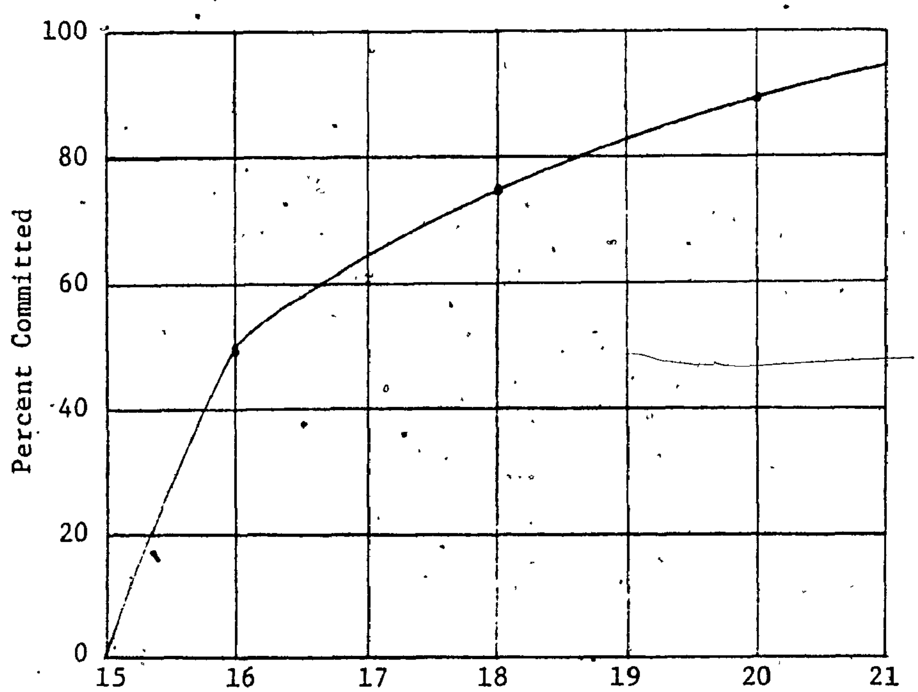
contingency on committed = (.05)(.9) = 4.5%
contingency on uncommitted = (.40)(.1) = 4.0% = 8.5%

Note: The above curve and that of Figure 2-3 were derived using numbers gleaned from actual projects.

Source: Criterion for Analyzing Contingency and Escalation, R. Cook, AACE Trans. 1978.

FIGURE 2-3

Contingency Analysis Curve for Bulk Materials



Percent Contingency on Uncommitted Items[1]

(1) Assume constant 10% contingency on Committed items

A. At 0% committed: Total Contingency = 15%

B. At 50% committed:

contingency on committed = (.10)(.5) = 5%
contingency on uncommitted = (.16)(.5) = 8% = 13%

C. At 90% committed:

contingency on committed = (.10)(.9) = 9%
contingency on uncommitted = (.20)(.1) = 2% = 11%

Source: Criterion for Analyzing Contingency and Escalation, R. Cook, AACE Trans. 1978.

At 90 percent committed, the total contingency is 8.5 percent. These numbers show that the rate of decrease of project contingency is slower than the rate of completion of the project.

This approach eliminates one of the most common pitfalls in analyzing contingency. Most estimates reduce contingency early in the project based upon receiving information on major items which tend to confirm the original estimate figures and ignore the fact that these items were in the category of activities which should have lower uncertainties than the overall average due to early design and procurement. Later in the project, large variances are encountered on items because the average contingency is insufficient for these activities.

These figures should serve as a guide for estimating an applicable contingency. Deviations from these figures are possible depending on particular circumstances. Table 2-4 in Section 2.4 outlines contractor's and owner's contingency appropriation for specified contract types.

2.4 CONTINGENCY AND CONTINGENCY APPROPRIATION IN CONSTRUCTION CONTRACTS

The owner, through his engineering consultant prepares on the basis of available resources and knowledge, designs, plans, specifications and a cost estimate that has been formulated as accurately as possible at the pre-award stage. The owner then sends out invitations to bid to prospective contractors. Whether a negotiated or competitive contract system is used depends on many factors. For either, estimates of cost have to be made by each prospective contractor. After review of the documents, the contractor (if he accepts to bid) does his own estimate and submits his proposal. In specific contractual arrangements between an owner and a contractor, no allowance is made in the contract for the contractor's contingency irrespective of the contract type as seen in Table 2-3.

TABLE 2-3

Major Types of Construction Contracts and Their Contingency Provision

Type of Contract	Comments	Contingency Provision
Fixed Price	Contractor must include all known contingencies with his bid	none
Cost Plus	All incurred costs are billable directly to owner	not required
Unit Price	Contractor must build in contingencies to his bid unit prices	none

The owner's designated estimator has determined, prior to the issuing of invitations to bid, the project direct costs, pre-award contingencies and escalation, and developed a full cost estimate based upon the known scope at the time. However, information received from the contractor may cause the owner's estimator to rethink some of his figures and as a result a post-award revised cost estimate may be necessary on the part of the owner.

Table 2-4 gives a comprehensive breakdown of contractor and owner circumstances and total estimate formation corresponding to a particular circumstance. This table may not be relevant in all cases but it should serve as a guide. However, the contingency allowance gap has widened since 1971 when this article was published.

After the award of the contract, the owner and contractor monitor actual costs that are generated. Continuous comparisons between actual costs and base estimates are made. Original estimates are modified to include actual costs as the costs become available. In this way new projections and modified estimates are made of the remaining portions of the project. This process is repeated through the life of the project by the owner and through the construction stage by the contractor. The recording and analysis of actual costs is a valuable process if the quality of the estimates and job performance is to be improved. The next section looks in detail at contingency in cost control.

TABLE 2-4

Table of Contractor's and Owner's Contingency Appropriation For Contract Types

Circumstances	Total Estimate Formation*	Estimate Relative Index
Contractor Bidding, Lump Sum	Contr. Est. + 5%	105
Contractor Bidding, Lump Sum (Hungry) (Optimistic)	Contr. Est. + 2%	102
Contractor Bidding, Reimbursable Cost Contract	Contr. Est. + 10%	110
Owner Interested in Appropriating	Owner's Est. + 15% (to provide let's say 1 chance in 10 of 10% overrun)	15
Owner's Expected Cost	Owner's Est. + 10%	110
Owner Thinking of Project as R & D	Owner's Est. + 30%	130

* Assuming all have identical estimating capabilities but various personal experiences as to contingency requirements to meet their own end uses.

SOURCE: "Contingency" - Cost Control Committee N.J. Section - AACE Trans., 1971.

2.5 CONTINGENCY AND COST CONTROL

251 GENERAL

Cost monitoring is an instrument of cost control. It is done on a predetermined periodic basis during the phases as indicated in Table 2-5.

TABLE 2-5

Project Phases and Corresponding Cost Monitoring Sequences

Phase	Cost Monitoring Sequence
Conceptual Design	on estimate based on design solution or solution alternatives
Design Development and Documentation	on each bid package at certain percentages of completion (say 30%, 60%, and pre-bid); also on overall re-estimate (if done)
Procurement	on analysis of bid
Construction	at regular time intervals (generally monthly) inclusive of tabulation of costs incurred and estimate of costs remaining to be incurred

Contingency is incorporated into the basic budget as indicated in Table 2-6. Contingency itself must be analyzed throughout the project duration to ensure proper interpretation of the total forecast of costs. By analyzing contingency on a periodic basis, the revised forecast values will yield the net effect of the project estimate. The result may indicate that the contingency has been reduced (or increased) by some dollar amount. This change is due to a change in uncertainty as the project progresses.

TABLE 2-6

Tabular Format for Incorporating Contingency into the Basic Budget

Basic Budget Element	Cost	Contingency Allocation	New Budget in Current Dollars*
Labour	250,000	6%	265,000
Material Cost			
a) Machinery	125,000,000	10%	137,500,000
b) Equipment	30,000,000	15%	34,500,000

* The new budget in current dollar figures should be used in the determination of escalation as discussed in Chapter 3.

Table 2-6 is included for illustrative purposes only and the contingency allowance may of course, vary substantially from that given. The new budget in current dollars then allows for uncertainty in the cost of the elements considered.

The effective use of periodic cost reports indicates the contingency reserve status, that is, how much of the contingency provision remains undepleted. These reports will also assess what contingency provision is still required on each item of uncompleted work.

Table 2-7 illustrates a project estimate status report for one project. The table is divided into two parts. The first part (A) denotes the determination of the original cost estimate by incorporating contingency and escalation into the base construction cost. The second part (B) shows how contingency and escalation are accounted for in a project status report at a specified time when work is in progress. Part B has the costs shown by contract package for a sewage treatment plant. Each package has a detailed breakdown of contingency and escalation for periodic accounting purposes. Both contingency and escalation have an original allowance. This amount may be in excess of or less than the required amount as determined by computation. The reserve amount is calculated and the forecast to complete is predicated. The sum of these two indicates the amount necessary (at the time of compiling the report) to complete the project. The variance is the difference between the required amount and the original amount. The projected final cost then becomes the algebraic sum of the original cost estimate plus the contingency variance plus the escalation variance. The total cost line denotes the sum of the contract packages under each respective heading. This type of project status report can be useful in monitoring the project as well as giving the project manager a quick overview of the project status. A report of this type could be computerized to facilitate its periodic generation.

TABLE 2-7

Project Estimate Status Report

A) Determination of Original Estimate Cost

Contract Package	Base Construction Cost	Engineering Design	Project Management	Contingency Allowance	Escalation Provision	Original Cost Estimate
Work Not Started Sewage Treatment Plant (Civil)	24.80	1.20	1.25	1.25	3.75	32.25

B) Project Status with Contingency and Escalation Accounting

Contract Package	Original Cost Estimate	Contingency: Original Allowance	Committed to Date	Reserve	Forecast to Complete	Required Allowance	Variance
Work in Progress Sewage Treatment Plant	(1)						(2)
Civil	32.25	1.25	0.50	0.75	0.85	1.35	+0.10
Mechanical	121.00	4.61	1.25	3.36	0.55	3.91	-0.70
Electrical	62.50	2.63	0.87	1.76	0.47	2.23	-0.40
Total Cost	215.75	8.49	2.62	5.87	1.87	7.49	-1.00

B) (Cont'd)

Contract Package	Escalation: Original Provision	Committed to Date	Reserve	Forecast to Complete	Required Provision	Variance	Projected Final Cost	Variance
Work in Progress Sewage Treatment Plant						(3)	(1)+(2)+(3)	(2)+(3)
Civil	3.75	1.95	1.80	2.05	4.00	+0.25	32.60	+0.35
Mechanical	13.25	6.75	6.50	7.21	13.71	+0.46	120.76	-0.24
Electrical	6.95	2.95	4.00	2.47	6.47	-0.48	61.62	-0.88
Total Cost	23.95	11.65	12.40	11.73	24.18	.0.23	214.98	-0.77

NOTE; + indicates an overrun, - indicates a surplus.

Figure 2-4 and Figure 2-5 show the original basic budget, plus escalation, plus IDC and the original contingency provision for a project life cycle. Figure 2-4 indicates that the project always has a contingency in reserve even at commissioning. This reserve obviously delights the project manager and owner since they term this savings a profit. For both figures, the committed contingency fund is referred to as the "Depletion of Contingency" and the reserve fund is called the "Contingency in Reserve". Figure 2-5, however, shows that the original, appropriated fund was insufficient for the project and that additional funds were required. These additional funds are referred to as "Appropriations". An appropriation is basically an amount to cover for uncertainties that were poorly estimated or neglected or to cover intangibles and unforeseens that may be required to complete the work of the contract. It is implicit here that monitoring contingency is done activity by activity as shown in Table 2-7. The basis of any contingency appropriation is done strictly by activity. It is important to note that the contingency in reserve funds should not be tampered with because any misuse or reallocation of funds may result in insufficient contingency remaining during the project phase and subsequent phases to cover for the potential uncertainties for which it was originally planned. An appropriation of funds must be closely scrutinized and the project manager, who acts on the authority of the owner, should be the only individual who possesses the authority to order such a procedure.

FIGURE 2-4

Depletion of Contingency

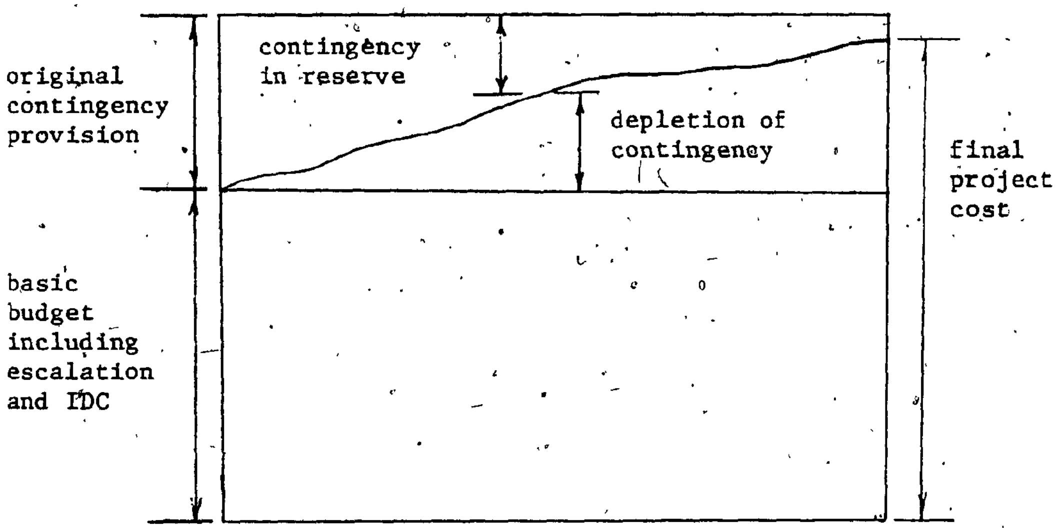
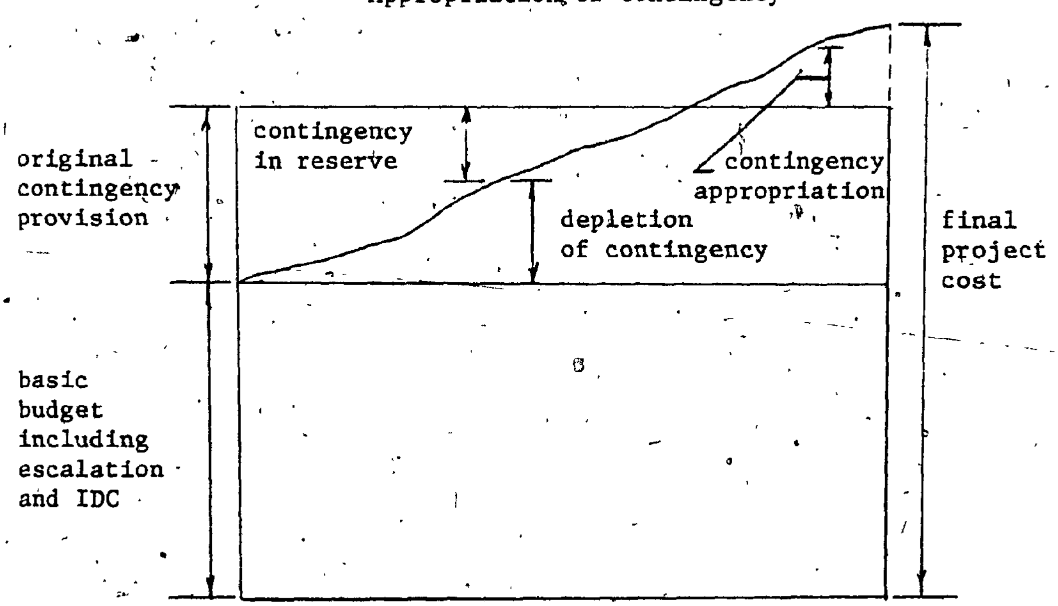


FIGURE 2-5

Appropriation of Contingency



2.6 METHODS OF CALCULATING CONTINGENCY

(1) Overall Percentage

This method is very popular (although not the method used in appropriation above, nor the recommended method to use on more than a few activities) and is widely used among contractors, consultants and owners. It is a simple technique which takes the least amount of time of all methods. This method is essentially one that has an overall percentage applied to the bare cost estimate. The determination of the percentage to be applied is primarily that of past experience. Actual costs are compared to estimated costs for completed projects in order to obtain the required percentages. The final percentage to be applied to the estimate is viewed in light of "special knowledge acquired" or the lack thereof.

Example:

Cost of Water Purification Plant

Divisions		Base Cost Estimate Excluding Escalation
1 - Civil Works		$ 500,000.
2 - Mechanical Works		2,625,000.
3 - Electrical Works		120,000.
4 - Indirect Costs		300,000.
Total Cost in Current Dollars	=	$3,545,000.
Apply Contingency of 15%	=	532,000.
Total Forecast Cost	=	$4,077,000.

This example illustrates the overall percentage method. The degree of accuracy of this method (except for small projects) is questionable.

(2) Detailed Percentage

The detailed percentage method is similar to the overall percentage in that every estimated cost has an allowance for uncertainty. However, the similarity ends here. The detailed percentage method considers each item or activity independently and provides for an appropriate contingency allowance to each one individually.

By studying completed projects, the estimator should be able to derive percentages for each item.

Example:

Consider the Water Purification Plant
(a simple breakdown by division)

Divisions	Base Cost Estimate Excluding Escalation	Contingency	New Cost
1 - Civil Works	$ 500,000.	10%	$ 550,000.
2 - Mechanical Works	2,625,000.	15%	3,019,000.
3 - Electrical Works	120,000.	10%	132,000.
4 - Indirect Costs	300,000.	20%	360,000.
		Total Forecast Cost =	$4,061,000.

If the percentages above were based on past experience, the difference between the two methods would be small indeed. However, these two examples are hypothetical and variation in the order of 10% or more could result between the two methods for some projects.

(3) Allowing for Estimate Error

Experience has shown that in estimating, the chance of omitting some portion of the work is far greater than the chance of double-counting some portion. Furthermore, while some detail may be incomplete, another will not be overcomplete. Therefore the likelihood of underestimating is greater than overestimating. An article titled "Bidding Contingencies and Probabilities" by M. Gates[41] sets forth the following procedure for allowing for estimate error.

If the quantity of units of work is represented by: Q:

$$\frac{(100 - s\%)q}{100} < Q < \frac{(100 + g\%)q}{100}$$

Q = the most likely quantity

q = the estimated quantity

g = the greatest possible error

s = the smallest possible error; not zero.

Assume that $Q = (1 + g)q$ will occur as often as $Q = (1 - s)q$, and that these deviations are triangularly and symmetrically distributed about Q rather than q, and that the smaller error s is 1/3 of the larger error g.

$$Q = \frac{(1 - s)q + (1 + g)q}{2} = q(1 + s)$$

Standard deviation σ is:

$$\sigma = \frac{(1 + g)q - (1 - s)q}{5} = \frac{4qg}{15} \approx \frac{qg}{4}$$

Coefficient of variation VQ is:

$$VQ = \frac{\frac{qg}{4}}{q(1 + \frac{g}{3})} = \frac{0.75g}{3 + g} \times 100\%$$

Consider this example:

The number of bricks required for a certain project is calculated as follows: 62,000 sq ft of wall x 6.5 bricks per sq ft x 1.03 waste = 415,000 pieces. Assume that this method of determining brick quantities has been found, from past experience, to err by as much as 10% due to variation in joint thickness, pilferage, failure to include all work shown on the plans and other unidentified reasons.

Most probable value Q is [1 + (0.10/3)] x 415,000 = 429,000. Standard deviation σ is (1/4) x 0.10 x 415,000 = 10,400 pieces and coefficient of variation V is 10,400/429,000 x 100% = 2.4% or (0.75 x 0.10)/(3.00 + 0.10) = 2.4%.

The above example shows that a 10 percent contingency has been applied to this singular estimate as determined from past experience and the resulting standard deviation yielded 10,400 pieces with a coefficient of variation of 2.4 percent. This small variation indicates the magnitude of uncertainty in the estimate, but not the range of uncertainty as can be found by using method number (5).

(4) Risk Analysis

This is a more sophisticated technique and has the following benefits:

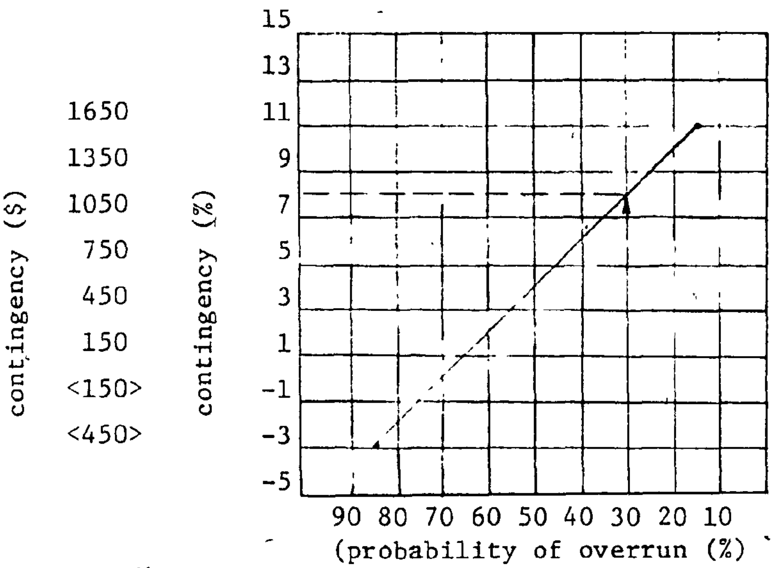
(a) Individual cost variables are assessed by the estimator and project team as to probability of underrunning and overrunning the base estimated costs, thus leading to a more objective and collective probability.

(b) Management can be presented with a formal statement that expresses the resultant range of risk, the most probable cost and the contingency (and attendant risk) selected by the project team.

From the above data, management decisions can be made intelligently in light of the business environment and competitive market. Thus, when management decides to proceed with a project at a forecast cost, it knows within reasonable limits, the risk in meeting that cost in terms of both dollars and probability. This can be observed from Figure 2-6.

FIGURE 2-6

Graph of Contingency versus Probability of Overrun



Estimate:

Est. cost excl. contingency $15,000

Accuracy excl. contingency = +11% - 3%

Most probable cost $15,600

Contingency = 8%, $1,200

Source: Risk Analyses - D.W. Campbell
Bechtel Corporation, AACE Bulletin, Vol. 13

The contingency graph above is the way the cost engineer presents his valuation. The sample shows that the estimated cost excluding contingency is $15,000. The two scales on the left express contingency in percent and dollars with each percent, for this example, equal to $150. The most probable cost is presented as $15,600, assuming a symmetric distribution. The sloping line equates the probability of overrun of the estimated cost with different levels of contingency. Management then decides what contingency to use based on the risk they are willing to take. For this example, management decided to take a 30% probability of overrun. The dashed line shows that the contingency required is 8% or $1,200. The accuracy of the estimate is defined as +3% - 11%. The sloping line ranges from about -3% to +11% or a spread of 14%. The 8% contingency used, leaves a possibility of a 3% overrun and an 11% underrun, thus an accuracy of +3% - 11%. These bounds assume that they have no more than a 15 percent probability of being exceeded.

Risk analysis is actually a comprehensive statistical technique which qualifies the uncertainty relative to the project estimates and thereby enables the owner to select an original contingency provision which will have a satisfactory probability of being sufficient. These analyses techniques represent complex correlations between interdependent resources and commodities. This tends to limit their use to the earlier estimating stages of the project as they would become too cumbersome to assist in cost control unless computer assistance was available.

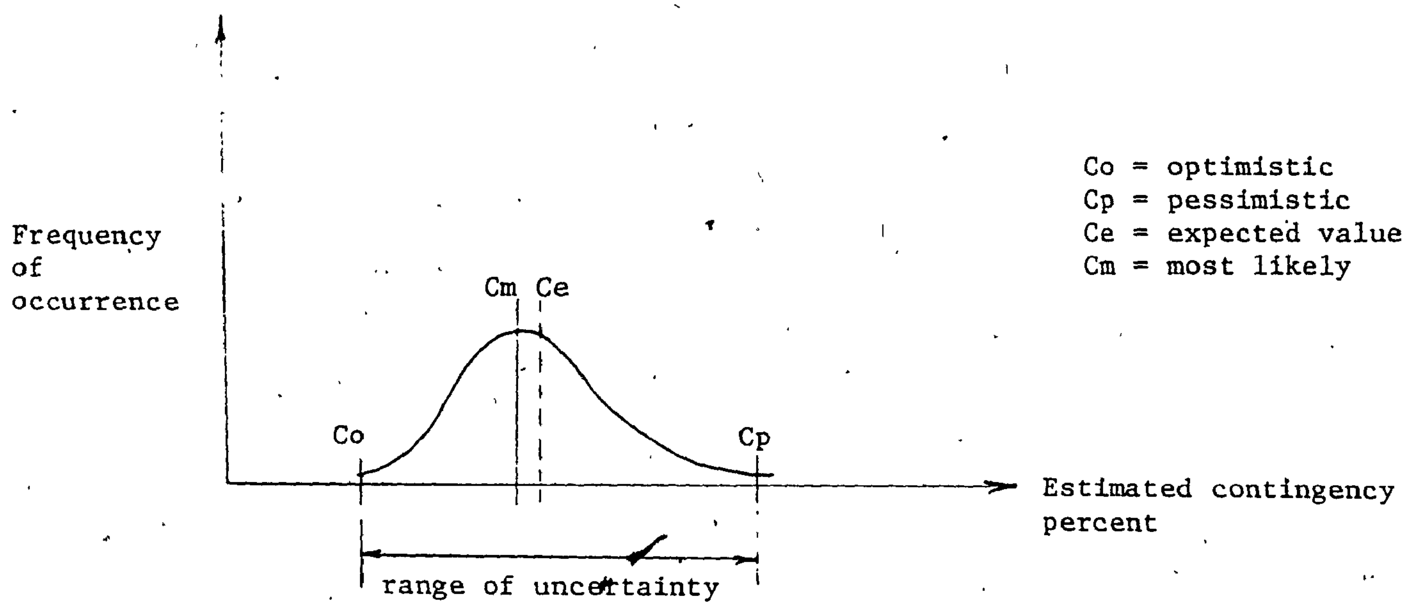
(5) Application of Pert Principles to Contingency Determination

For particular estimates that have items or activities that involve uncertainty, an expert assessment should be able to determine a lower and upper bound for contingency appropriation. Somewhere between the two extremes a most likely value can also be determined.

These three values are illustrated in Figure 2-7.

FIGURE 2-7

Beta Distribution of Variables



The most pessimistic or upper bound for contingency represents the percentage appropriation, should the most unfavourable consequences occur. Conversely, the optimistic or lower bound contingency represents the appropriation should the most favourable outcome occur.

The three contingency estimates can be fitted to a beta distribution which has convenient mathematical properties and which can adopt a wide range of shapes. The basis for adoption of this distribution is to allow computation of the expected contingency Ce. Figure 2-7 has Ce plotted. This expected value can be more or less than the most likely value. Ce is the centroid of the distribution and results tend to gravitate toward it. It is essentially an average.

As used by Pert (Program Evaluation and Review Technique) the value Ce can be expressed as follows:

$$Ce = \frac{Co + 4\ Cm + Cp}{6}$$

The variance S^2 Ce which is a measure of the dispersion of the probable occurrence about the expected value is expressed as follows:

$$S^2\ Ce = \left(\frac{Cp - Co}{6} \right)^2$$

This variance increases as the range between Co and Cp increases and vice versa.

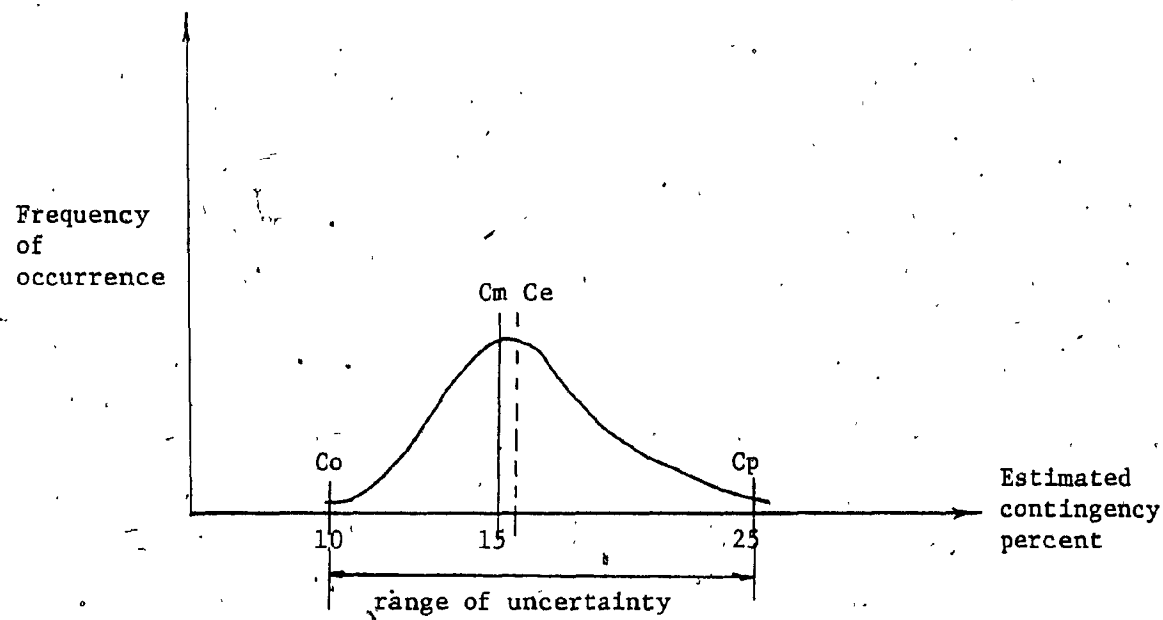
<u>Example</u>:

Let's consider labour as an activity for a package to which a contingency need be applied to allow for uncertainty.

The estimator feels that because of recent labour unrest in the locality, and rumblings about future strike action over unresolved contract disputes, that an upper bound contingency for labour cost would be 25 percent. On the other hand, should labour negotiations clear up some of the grievances, a contingency of 10 percent would be applicable. However, the most likely contingency is estimated at 15 percent. Figure 2-8 represents the beta distribution plot of the frequencies of these percentages which result in the unsymmetrical curve as shown.

FIGURE 2-8

Beta Distribution for Labour Contingency



The three estimates, rather than one estimate express the contingency for a particular activity, which in this case is labour. The probability of either the lower bound or upper bound contingency being attained is about 0.01. Thus, the contingency that is closest to the expected is the most likely one. In this example the probability of the contingency being 10 percent or 25 percent is 0.01. Therefore, the expected contingency should be near 15 percent.

$$Ce = \frac{10 + 4(15) + 25}{6} = 16$$

The expected contingency is therefore 16 percent.

The variance is computed as follows:

$$S^2 = \frac{(25 - 10)^2}{(\ 6\ )} = 6.25$$

$$S = 2.5$$

The variance which describes the uncertainty is small in this case. If it is large (when lower and upper bound values are far apart), there exists great uncertainty about the expected contingency.

Should several activities have their contingencies determined in this way, the expected contingency for the group of activites and the resulting probability distribution may be determined by use of the "central limit theorem". This theorem enables the estimator to approximate a single probability distribution called the "normal distribution". The normal distribution may closely approximate the likely path of any contingency occurrence as deviation occurs away from the mean value. The total expected contingency CE can be found using the formula:

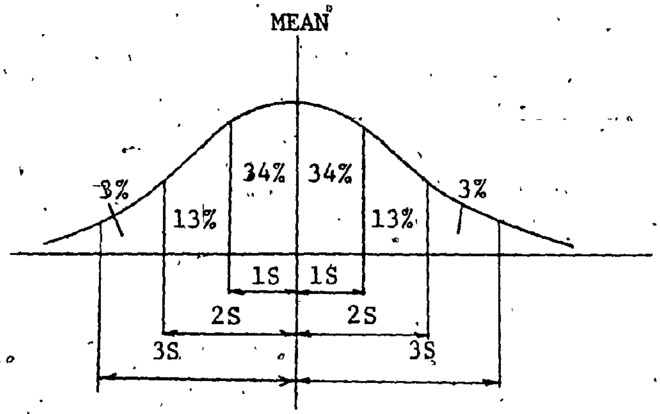
$$CE = \sum_{i=1}^{n} Ce_i \quad \text{for n activities}$$

The total variance = S^2

$$S^2 = \sum_{i=1}^{n} S^2 Ce_i \quad \text{for n activities}$$

FIGURE 2-9

Normal Distribution Curve



Source: "A System for Managing Escalation and Contingency", K.C. Carrier, AACE Trans. 1977.

The contingency that is most likely, Cm is the sum of the values arrived at for activities considered.

The above figure represents a typical normal distribution curve. It denotes the percentage areas under the curve that lie between various limits. The above limits are defined in terms of standard deviation (S).

CHAPTER 3

ESCALATION

3.1 INTRODUCTION

In order to evaluate, monitor and forecast the total cost of a project as construction proceeds, it is necessary to analyze escalation and contingency (discussed in Chapter 2 of this paper) as well as direct costs. Too often, escalation and contingency are treated as perpetual reservoirs from which to draw monies in order to cover cost overruns. This is a misuse of these funds and frequently provides misleading results. Inflation, by itself, has a tremendous impact on project costs and as often as not any substantial deviation between costs at two different times has been blamed on inflation. This excuse has been poorly received by owners who subscribe to the point of view that inflation is often used as an excuse to cover-up for poor cost estimating, cost control and project management.

This chapter on escalation will define escalation and review the role of escalation in the different phases of project development. A discussion of inflation to the detail required to ensure an understanding of the role it plays in price and cost increases will be included. Finally, the paper will discuss escalation and contracts, escalation calculations and methods of forecasting escalation rates.

3.2 INFLATION

321 GENERAL

A thorough understanding of inflation and its affects is necessary prior to discussion of escalation.

Basically inflation is said to occur when more and more money is required to purchase some representative bundle of goods and services. It is a sustained fall in the purchasing power of money, or, what comes to exactly the same thing, a sustained rise in the general level of prices. The above definition is important since in everyday conversation it can be heard that a particular cost has risen and the event is attributed to inflation. This statement might be correct if the price is really a typical one and if most prices have been rising in terms of money. However, the description need not be true even if there were no inflation at all; if the price of a representative bundle of goods and services were absolutely flat, it could still be that the price of wood, fuel or property is rising while some equally significant price of automobiles, generators or steel is falling. In any live economy, the prices of goods are expected to change in terms of each other, because relative costs of production change, fashions change, or a cartel forms. Though these changes in relative prices may have something to do with the generation of inflation, they are not the same thing as inflation. Inflation occurs only when some representative average of prices is rising in terms of money.

This distinction between relative prices and the general price level is important to grasp. A pure inflation can be defined as an inflation in which all prices are rising at exactly the same rate, the ratio of any one price to any other particular price remaining the same. If actual inflation were like pure inflation no confusion would arise. In reality, both things happen at once; prices rise on the average and some prices rise faster than others.

The following example will further develop an understanding of this phenomenon. Between December 1976 and December 1977 the consumer price index (which is the cost of one of those representative bundles of goods and services) rose by 6.8 percent. In those same 12 months, the price of clothes rose by 4.2 percent, while the cost of medical care went up 8.8 percent. This reflects that those in the medical care field were much more fortunate than those in the clothing industry. What is often forgotten in everyday discussion is that those in the medical profession and those in the clothing industry would have been in the same relative position if there had been no inflation at all (the consumer price index remaining unchanged) while the cost of medical care went up 2 percent and the price of clothing went down by 2.6 percent. This firmly distinguishes between relative costs and the general price level, which may be connected but are definitely not the same. Inflation itself, has to do with absolute prices, in money terms. The following sections will expound on the different causes of inflation.

322 COST-PUSH INFLATION

This type of inflation is essentially one where too much money spending (i.e. consumption, investment and government spending) bids for the limited supply of goods and labour available at an employment level and pushes up prices and wages. If, for example, a demand for higher wages is met, the wage increases will increase the cost of production which sends up the prices that firms charge for their goods. The result is a form of cost-push inflation. If sellers, whether of labour or of property services or of goods negotiate and determine their prices to try to get among them more than 100 percent of the total national product, then the result cannot help but be an upward push in the price level - a case of sellers' inflation. To clamp down on monetary and fiscal policy to fight such inflation will only result in unemployment and stagnation. But not to act is to accept creeping inflation that may accelerate.

323 DEMAND-PULL INFLATION

If the total of consumption plus investment plus government spending exceeds the value of what the economy can produce at full employment, demand dollars will beat against the limited supply of producible goods and services and will bid up their prices. Since labour is a service and since at such times the labour market has become very tight, the bidding up of wages is also part of the process. The direction of the above cause is definite; it proceeds from demand to inflation. Essentially then, too much money chasing after a limited supply of goods constitutes demand-pull inflation.

324 INTEREST-PUSH INFLATION

As individuals and companies come to anticipate a steady rate of inflation, they build into their interest rate supply and demand schedules an allowance for inflation. If an allowance is built in, a corresponding cost increase is built in as well.

325 FOREIGN TRADE AND INFLATION

The channels through which foreign inflation can spill over to domestic prices are many and their mechanisms quite distinctive. Essentially, inflation is imported when domestic price levels rise. The casual link may be direct or indirect depending upon how changes in prices of individual commodities abroad lead to changes in these same commodities at home. Inflation basically refers to a sustained increase in prices and requires as a necessary condition an accompanying increase in the domestic money supply. Without such support, increases in prices will eventually result in marked disequilibria which in turn will require a reversal of the increases to restore equilibrium. If the initial price increases arise from foreign pressures, the foreign exchange market will suffer from disequilibrium as long as the exchange rate is pegged by government action. If the money supply is not increased, this disequilibrium can only be removed by altering the exchange rate so that the foreign price changes are exactly offset and domestic prices of foreign goods are unchanged.

If foreign inflation is continuous, then the exchange rate must rise continuously to preserve equilibrium. Alternatively, the money supply may be permitted to expand and domestic prices will rise in step with foreign prices with no effect on individual markets within the country, provided that all agents buy and sell with full knowledge of the ongoing inflation.

If the foreign exchange rate is not free to fluctuate or if domestic markets are not perfectly adaptive to foreign price changes, then inflation abroad will spill over to the domestic economy and place upward pressure on domestic prices.

The foreign exchange market may also be out of equilibrium if prices at home and abroad are not rising together. Under this condition, purchasers of some commodities, both at home and abroad will switch to suppliers at home, creating an excess supply of foreign exchange. This offsets the reduction in output but reinforces the disequilibrium in the domestic money market because monetary authorities must neutralize the influx of foreign exchange to prevent an "inflationary" expansion of the money supply.

3.3 ESCALATION IN PROJECT DEVELOPMENT

The following figure, Figure 3-1, illustrates a typical project life cycle from the feasibility stage to commissioning and Table 3-1 establishes the framework of how escalation is incorporated into the project basic budget.

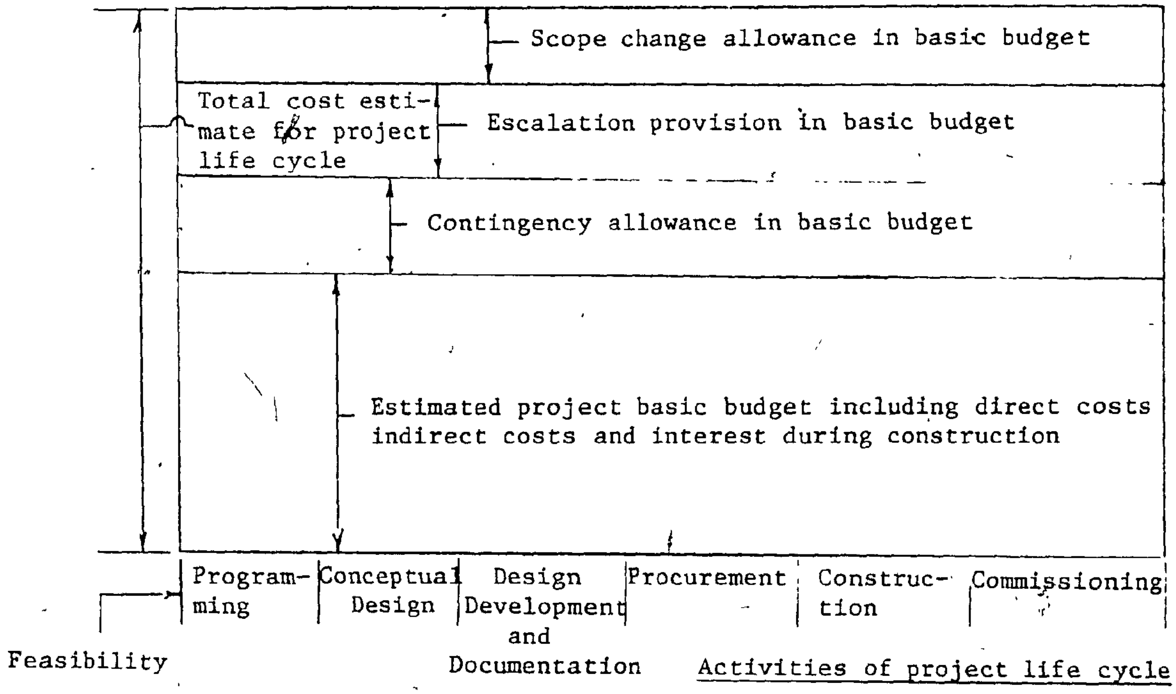


FIGURE 3-1:

Total Cost Estimate for Project Life Cycle

TABLE 3-1

Table Used to Incorporate Escalation into the Base Cost Budget

Base Cost Budget*				Adjustment for Escalation			New Budget in Current Dollars
Labour	Material	Equipment	Total	Labour	Material	Equipment	
100	50	300	450	+8%	+10%	+15%	508

* The base cost budget in this table should include the contingency allowance as discussed in Chapter 2.

This project life cycle as shown in Figure 3-1, outlines each stage in the project development. A basic budget is determined for the project at the initial stage. At this early stage (feasibility) a contingency allowance is applied for uncertainties (as discussed in Chapter 2), an escalation provision, as calculated by using Table 3-1 is applied to account for higher expected costs and thirdly, a scope change allowance is provided (in some circumstances). It is obvious that as the project approaches completion and the number of uncertainties diminish, the scope change allowance and contingency allowance will be either depleted or supplemented. For long life projects (i.e. several years) the escalation provision will have to be readjusted periodically. Accounting for escalation is shown on Table 2-7.

In order to do proper financial planning, the project management team must have more than just the total estimated cost of construction at today's prices. They must know how many dollars will be required and when in time they will be spent. Such information is provided based on practical detailed schedule and cash flows. It is very important to have a well thought out project schedule in order to ascertain the project life and assign dollar values to aspects of the project in accordance with the time value of money concept.

The project cash flow is generated from cost information provided from labor, material and equipment details in the estimate. For example: material and equipment payments are based on scheduled delivery dates; labour payouts are based on the time period in which the activity takes place.

Table 3-2 illustrates a typical project cash flow. Generally a detailed cash flow is calculated for each year of the project. The direct costs are those for tangibles and indirect costs cover such items as engineering, project administration, quality assurance, owners expense, personnel training and other intangibles. This type of cash flow allows the project manager and owner to effectively monitor performance on the project. The cash flow incorporates direct and indirect costs to account for the basic budget and then includes escalation, contingency and scope change allowances as well as interest to the Owner during construction. Note that the period of escalation is from the date of estimate to the scheduled dollar expenditure.

To compute periodic escalation adjustments, a series of escalation indices must be selected for the project. These indices will cover such items as labour, materials and energy. It is important that both the owner and the project manager agree on the figures chosen. These indices should be based on published data from various reputable sources. Where some elements of the project cannot be satisfactorily associated with a basic index, a composite index composed of a precisely specified mix of two or more standard indices can be incorporated. Periodic reviews of the indices should be made to register the actual (published) values and to revise forecast values.

The following tables will better enable the reader to visualize the extent of escalation during the last few years.

TABLE 3-2

Detailed project cash flow of budget cost (in thousands)

1979		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Direct Cost	M	820	0	0	0	0	0	0	0	0	0	0	0
	C	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200	3200
Labour		10	0	0									
		200	200										
Material		20	30										
		600	630										
Equipment		45	55										
		520	575										
Total Direct Cost		895	85										
		4095	4180										
Indirect Expenses		100	110										
		450	560										
Total Direct and Indirect Cost		995	195										
		4195	4390										
Contingencies													
Labour		1	2										
		20	22										
Material		4	4										
		120	124										
Equipment		7	7										
		78	85										
Escalation													
Labour		1	1										
		18	19										
Material		3	4										
		115	119										
Equipment		6	10										
		65	75										
Scope Change Allowance		2	3										
		4	7										
Sub-Total		1019	226										
		4219	4445										
Billing		4219	226										
Retainer		422	23										
Total Project Payment		3797	203										
Int. During Construction		380	20										
Grand Total Cost		4599	4845										

M - Monthly
C - Cumulative

Note: The above shows figures for two months for a hypothetical project for illustrative purposes only. In a real cash flow all months would be tabulated.

Source: Impact of Escalation on Power Plant Cost Estimates, R.A. Barry, Sargent and Lundy, Engineers, Chicago, U.S.A.

Table 3-3 and Table 3-4 denote the historic price indices for hydroelectric plants and steam electric plants respectively.

Table 3-5 contains the builders construction cost indices from 1974 to December 1978.

Table 3-6 shows the variation in consumer prices for several western nations from 1962 to 1976. This particular table was inserted to give the reader an idea of the order of magnitude of cost increases being experienced in other western nations relative to Canada and the United States (which stay nearly the same in terms of relative changes in annual cost increases).

There are many sources of construction cost indices. Some of these are listed below:

Canada:
(1) Consumer Price Index (CPI);
(2) Non-Residential construction price index (NRCI);
(3) Non-Residential construction labour index;
(4) Non-Residential construction material index.

U.S.A.:
(1) Exxon Report;
(2) Mobil Report;
(3) U.S. Government Bureau of Labor Statistics;
(4) U.S. Government Department of Commerce;
(5) Nelson Inflation Index;
(6) Chemical Engineering Plant Cost Index;
(7) Marshall & Swift Equipment Cost Index;
(8) Engineering News-Record Construction Cost Index;
(9) Miscellaneous Publications from Other Sources.

Since escalation indices are available, it is possible to develop the expected escalation for each item of a specific work package (activity) given the time and cost information. The estimator must calculate the escalated amounts on a month by month basis over the planned duration of the activity, based on the anticipated cost

TABLE 3-3

Historic Price Indices Hydroelectric Plant
(Weights in Brackets)

	Total (100)		Structures (47.1)		Equipment (23.6)		Temporary Camps 10.8		Engineering & Administration (18.5)	
	Index 1961=100	Annual % Change	Index 1961=100	Annual % Change	Index 1961=100	Annual % Change	Index 1961=100	Annual % Change	Index 1961=100	Annual % Change
1961	100.0		100.0		100.0		100.0		100.0	
1962	102.7	2.7	103.5	3.5	102.8	2.8	101.0	1.0	102.9	2.9
1963	106.1	3.3	109.2	5.5	104.8	1.9	103.5	2.5	104.6	1.7
1964	109.6	3.3	112.7	3.2	109.2	4.2	106.2	2.6	108.0	3.6
1965	115.0	4.9	119.2	5.8	113.1	3.6	111.2	4.7	115.1	6.2
1966	122.1	6.2	127.0	6.5	116.9	3.4	117.9	6.0	122.4	6.3
1967	126.5	3.6	131.5	3.5	116.3	-0.5	123.2	4.5	131.0	7.0
1968	131.6	4.0	136.5	3.8	115.3	-0.9	126.4	2.6	139.8	6.7
1969	139.5	6.0	144.5	5.9	118.7	2.9	132.9	5.1	150.8	7.9
1970	148.3	6.3	153.4	6.2	126.3	6.4	138.0	3.8	163.0	8.1
1971	155.2	4.7	164.0	6.9	131.3	4.0	145.5	5.4	172.9	6.1
1972	164.9	6.3	177.0	7.9	135.1	2.9	156.7	7.7	185.0	7.0
1973	178.3	8.1	195.6	10.5	140.7	4.1	174.4	11.3	197.0	6.5
1974	209.0	17.2	235.2	20.2	162.0	15.1	203.5	16.7	219.3	11.3
1975	241.2	15.4	278.1	18.2	188.8	16.5	229.7	12.9	246.1	12.2
	1971=100		1971=100		1971=100		1971=100		1971=100	
1971	100.0		100.0		100.0		100.0		100.0	
1972	106.3	6.3	107.2	7.2	104.5	4.5	109.5	9.5	107.1	7.1
1973	116.1	9.2	118.6	10.6	112.7	7.8	126.8	15.8	113.7	6.2
1974	137.9	18.8	147.2	24.1	129.2	14.6	147.9	16.6	126.4	11.2
1975	157.6	14.3	170.8	16.0	154.2	19.3	159.3	7.7	142.1	12.4
1976	171.3	8.7	186.4	9.1	168.2	9.1	173.9	9.2	156.2	9.9

Source: Statcan Construction Price Statistics Monthly 62-007 Table 9.1
Quarterly 62-008 Table 9.1.4

TABLE 3-4

Historic Price Indices Steam Electric Plant
(1971=100, weights in brackets)

	Total (100)		Structures (17.3)		Equipment (67.2)		General Overheads (5.3)		Engineering & Administration (18.5)	
	Index	Annual % Change	Index	Annual % Change	Index	Annual % Change	Index	Annual % Change	Index	Annual % Change
1966	79.1		78.5		81.0		74.1		71.2	
1967	80.0	1.1	79.8	1.7	80.4	-0.7	77.6	4.7	76.3	7.2
1968	82.2	2.8	82.1	2.9	81.0	0.7	81.4	4.9	81.6	6.9
1969	87.8	6.8	87.3	6.3	86.1	6.3	86.2	5.9	87.8	7.6
1970	94.3	7.4	93.2	6.8	92.7	7.7	93.1	8.0	94.3	7.4
1971	100.0	6.0	100.0	7.3	100.0	7.9	100.0	7.4	100.0	6.0
1972	106.1	6.1	108.1	8.1	105.8	5.8	107.9	7.9	107.5	7.5
1973	115.9	9.2	122.3	13.1	115.7	9.4	118.3	9.6	113.9	6.0
1974	139.6	20.4	155.8	27.4	139.3	20.4	137.1	15.9	127.4	11.9
1975	158.4	13.5	169.8	9.0	161.5	15.9	152.4	11.2	145.0	13.8
1976	174.5	10.2	180.8	6.5	180.7	11.9	172.3	13.1	159.5	10.0

SOURCE: Statcan Construction Price Statistics Quartery 62-008 Table 9.1.6.

TABLE J-5

Builders' Construction Cost Indexes

NAME, AREA & TYPE	1974 Av.	1975 Av.	1976 Av.	1977 Av.	% chg. 76-77	1977 Nov	1977 Dec	1978 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
GENERAL PURPOSE COST INDEXES																			
ENR 20-cities: Construction Cost	188	206	223	240	+7.6	248	249	249	250	251	251	254	256	263	263	266	265	266	267
ENR 20-cities: Building Cost	178	193	211	229	+8.5	237	239	238	239	240	240	245	246	251	252	255	255	256	257
U.S. Commerce Department	173	190	198	213	+7.6	-	-	230	231	231	231	231	240	240	242	243	-	-	-
BuRec, Denver, buildings	175	196	206	223	+8.3	-	-	228	-	-	235	-	-	245	-	-	249	-	-
Dodge building cost	205	230	266	277	+4.1	-	-	-	-	293	-	-	-	-	-	304	-	-	-
Factory Mutual industrial building	176	200	212	226	+6.6	-	-	241	-	-	-	-	-	250	-	-	-	-	-
Lee Saylor Inc.: labor/material	207	209	216	229	+6.0	-	-	243	-	-	245	-	-	250	-	-	255	-	-
Means: construction cost	176	188	198	209	+5.5	-	-	218	-	-	221	-	-	227	-	-	231	-	-
CONTRACTOR PRICE INDEXES - BUILDING																			
Austin: central & eastern U.S., industrial	176	187	198	208	+5.1	-	213	-	-	218	-	-	225	-	-	231	-		-
Fruin-Colnon: St. Louis, industrial	183	202	236	234	-0.9	242	244	245	246	248	250	254	258	260	262	264	265	269	-
Geo. A. Fuller	185	204	219	234	+6.8	-	-	250	-	-	259	-	-	267	-	-	272	-	-
Lee Saylor Inc.: subcontractor	188	167	177	196	+10.7	-	-	211	-	-	216	-	-	223	-	-	234	-	-
Turner: general	189	199	202	209	+3.5	-	-	215	-	-	219	-	-	224	-	-	229	-	-
Smith, Hinchman & Grylis: general #	176	186	199	213	+7.0	220	220	220	221	223	224	225	227	230	232	234	235	-	-
H.F. Campbell: 17-cities manufacturing	176	194	205	216	+5.4	221	221	223	224	224	229	229	233	233	233	239	239	-	-
VALUATION INDEXES																			
American Appraisal: 30-cities, industrial	179	189	206	220	+6.8	226	228	230	231	232	234	235	239	240	243	244	247	-	-
Boeckh Index: 20-cities, commercial & manufacturing	171	189	205	221	+7.8	228	-	229	-	233	-	236	-	239	-	242	-	247	-
Marshall & Swift: industrial	169	184	196	209	+6.6	-	-	223	-	-	227	-	-	233	-	-	239	-	-
SPECIAL PURPOSE INDEXES																			
Nelson Refinery Cost: "Inflation" Index	182	200	215	223	+3.7	220	221	236	237	238	239	240	242	-	-	-	-	-	-
Chemical Engineering plant cost	151	166	175	186	+6.3	191	192	193	194	195	197	198	199	200	202	203	204	-	-
Port Authority of N.Y. & N.J., hangar cost	175	194	204	217	+6.4	225	225	226	226	226	226	235	235	236	236	236	237	-	-

Base: 1967 = 100

* Adjusted for productivity, ** reinforced concrete, #Smith, Hinchman & Grylis is an A-E firm. ***Prepared by Boeckh Publications - a division of American Appraisal Associates, Inc. p - preliminary r - revised.

SOURCE: ENR, December 21, 1978

TABLE 3-6

Consumer Prices in Selected Countries
Percentage Changes from Previous Period,
not Seasonally Adjusted

	At Annual Rate				
	Average 1962-72	1973	1974	1975	12 Months to October 1976
Canada	3.3	7.6	10.9	10.8	6.2
United States	3.3	6.2	11.0	9.1	5.3
Japan	5.7	11.7	24.5	11.8	8.6
France	4.4	7.3	13.7	11.7	9.9
Germany	3.2	6.9	7.0	6.0	3.8
Italy	4.3	10.8	19.1	17.0	20.1
United Kingdom	4.9	9.2	16.0	24.2	14.7
TOTAL OECD (1)	3.9	8.0	13.6	11.5	8.1

NOTE: (1) Organization for Economic Cooperation and Development - includes 24 non-communist countries.

SOURCE: OECD, Economic Outlook, December 1976.

value of the activity completion during the month in question, assuming that the total cost of the activity is distributed uniformly over the duration of its working days. The sum total of the individually calculated monthly escalated amounts less the unescalated amounts yields the estimated escalation.

One area of concern in applying indices is the manner in which the project basic budget cost base was determined. In otherwords, the cost base of all items should be in terms of equivalent dollars. Care should be exercised to avoid mixing costs from pre-award contract packages and others which may have been re-estimated.

Normally on a small project, different escalation indices would not be used but a general construction index that would satisfactorily cover for activities of minor cost would be applied. However, on a larger project, the extra work involved in applying individual escalation indices would be well warranted especially if there is a reason to believe that there will be a significant difference between the rate of inflation on specific items over an estimated period of time.

3.4 ESCALATION AND CONTRACTS

Some contracts may contain an escalation clause that allows the individual or company who has entered into a contract with an owner to adjust a previously determined cost in a manner agreed to by both the owner and contractor. However, some contracts do not contain such a clause and in the circumstance where this occurs the contractor must consider a contingency to allow for potential unforeseen cost increases.

Clauses in owners contracts between owners and contractors vary from company to company and from contract to contract, but most of them include the following:

(1) A description of the specific elements of cost contributing to the determination of the initial contract costs that are not subject to cost escalation;

(2) A description of the specific elements of cost contributing to the determination of the initial contract costs that are subject to cost escalation;

(3) A stipulation of the index or indices from which changes in the cost of the elements in (2) are to be measured;

(4) An indication of the frequency with which the basic contract price will be adjusted to take into account changes in the relevant cost elements;

(5) A definition of possible limits to which the cost elements subject to escalation may be increased or decreased (should this be the case) during specific periods or over the length of the contract;

(6) In the case of foreign contracts involving payments in two or more currencies, a prior agreement must be reached on the method of calculating the effects of inflation on foreign exchange rates.

Table 3-7 below lists the major types of construction contracts and the way escalation is handled in each.

TABLE 3-7

Major Types of Construction Contracts and Their Escalation Provision

Type of Contract	Requirements for Use	Escalation Provision
Fixed Price	Complete plans, specifications and scope of work well defined.	Built into contract
Cost Plus	Scope of work does not have to be clearly defined.	Escalation is included in billings
Unit Price	Complete plans, specifications and scope of work well defined with approximate quantities known.	Built into contract

It should be mentioned here that inadequate consideration of the often detailed and complicated supporting explanations for escalation provisions in contracts has been the cause of frequent disputes and legal action concerned with whether or not and in what manner a clause may be invoked.

In order to further clarify the type of escalation clauses used in typical contracts for large projects, the following pages have been included to denote what is currently being used by most owners and consultants acting on behalf of owners. These clauses have been selected from "Montreal Engineering Company, Limited" contract specifications and are direct quotes from the source.

ESCALATION - GENERAL

Escalation is the amount by which the Tendered Amount of the Contract Price will be adjusted for variations in the cost of labour and material, in the manner specified herein.

Escalation Period

Escalation will be calculated for three month periods, hereinafter referred to as Escalation Period, the first Period starting the date of award of Contract; and subsequent periods starting at 3 month intervals thereafter.

Local and Foreign Currency

Escalation will be calculated separately for the local currency component of the Tendered Amount of the Contract Price and for each foreign currency component of the Tendered Amount of the Contract Price.

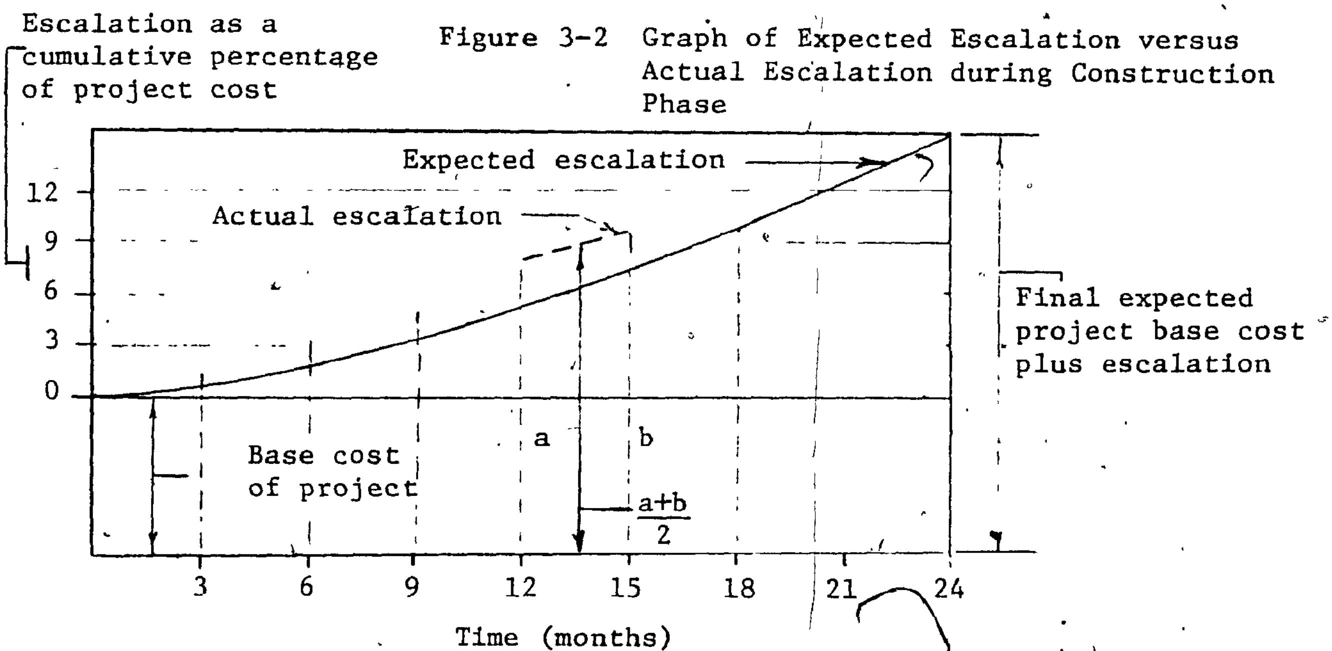
Indices

The Base Indices used to calculate escalation shall be the published indices at the latest date specified for receipt of Tenders in the Instructions to Tenderers. Proposed indices shall be published by an approved source which shall be a recognized national agency in the country of origin of the material to be supplied. For local labour and locally obtained materials, indices issued by or approved by the local government, shall be used.

The Cost Indices used to calculate escalation shall be the average of the published indices at the beginning and end of the Escalation Period.

End of contract quote.

Figure 3-2 Graph of Expected Escalation versus Actual Escalation during Construction Phase



a = cumulative escalation in 12th month.
b = cumulative escalation in 15th month.

This last clause deserves some comment. The time lag in publishing escalation indices from their forecast dates is an important consideration. For example, a contractor may consider an index number relating to a particular date to be in force until the day preceding the date of the next published index and may calculate a weighted average of cost indices over the escalation period which is the number of months or days that the index is presumed to be in force. Referring to Figure 3-2, which shows the expected escalation curve against time, it can be seen that for the period beginning in the 12th and 15th months (assuming indices are published every 3 months) that the actual escalation is in excess of the projected escalation for these two consecutive time periods. Also, the cumulative escalation percentage published in the 15th month is greater than the cumulative escalation percentage published in the 12th month. The actual cumulative escalation percentage over the interval between the 12th and 15th month should be the average, 'actual escalation', of both. In this case the value is the mean of the line joining a to b and is denoted on Figure 3-2 as $\frac{a+b}{2}$. The rates determined from the $\frac{a+b}{2}$ cumulative percentages should then be applied to the costs being billed for the period between the 12th and 15th months.

Continuation of contract clauses

Method of Calculation

Escalation will be calculated separately for the material component, the shop labour component and for the Site labour component of the prices entered in the Schedule of Prices.

The escalation on any amendment to the Contract that is negotiated in respect of changes in the Works shall be based on the date of quotation of the amendment unless the amendment is quoted either as not subject to escalation or as a firm price or as escalated on same basis as Contract prices.

3.5 ESCALATION CALCULATION

Calculations for a project are usually done by the weighted average method. This method is shown for a project escalation schedule shown on Table 3-8. Firstly, each item for a project package is assigned an escalation rate. The base cost of each item is determined and the Pct. of Total column denotes the percentage of the total package cost for the particular item. The weighted escalation then becomes the pct. of total cost times the specific escalation rate for a known time period. The sum of the weighted escalation figures multiplied by the base cost estimate plus the original base cost estimate gives the current cost figure. The advantage of this method is obvious in that each item has an individually assigned escalation rate which results in much more accurate project cost reporting.

Table 3-9 illustrates a table of actual and forecast escalation rates as they apply to hoists and cranes. With reference to this table, the multiplying factor or escalation rate between two dates can be obtained by dividing the index for the end date by the index for the starting date.

The percentage escalation is calculated by the following formula:

$$\text{Escalation Percent} = (\text{multiplier} - 1) \times 100.$$

** <u>Example</u>

What is the percent escalation for the 1000 Account between July 1975 and October 1980? (Refer to Table 3-9).

TABLE 3-8

Table of Forecast Escalation Rates on a Project Package

Acct. No.	Account Name	Pct. of Total	1973 Esc. Rate Pct.	1973 Wtd. Esc.	1976 Esc. Rate Pct.	1976 Wtd. Esc.	1977 Esc. Rate Pct.	1977 Wtd. Esc.	1978 Esc. Rate Pct.	1978 Wtd. Esc.	1979 Esc. Rate Pct.	1979 Wtd. Esc.	1980 Esc. Rate Pct.	1980 Wtd. Esc.	1981 Esc. Rate Pct.	1981 Wtd. Esc.	1982 Esc. Rate Pct.	1982 Wtd. Esc.
1000	Hoists and Cranes	.7	16	.11	6	.04	6	.04	5	.04	5	.04	5	.04	5	.04	5	.04
1500	Pumps and Drivers	.9	16	.14	5	.05	7	.06	7	.06	9	.08	9	.08	9	.08	9	08
1600	Boilers	.2	24	.05	4	.01	3	.01	8	.02	5	.01	5	.01	5	.01	5	.01
1800	Compressors and Blowers	.2	16	.03	3	.01	7	.01	8	.02	3	.01	3	01	3	.01	3	.01
1900	Storage Tanks and Spheres	.3	24	.07	7	.02	6	.02	6	.02	6	.02	6	.02	6	.02	6	.02
2000	Materials Handling Equipment	1.8	16	.29	4	.07	5	.09	5	.09	5	.09	5	.09	5	.09	5	.09
2100	Reduction Equipment	7.4	17	1.26	8	.59	6	.44	7	.52	8	.59	8	.59	8	.59	8	.59
2200	Separation Equipment	1.3	16	.21	3	.04	3	.04	4	05	3	.04	3	.04	3	04	3	.04
2300	Concentration Equipment	1.0	17	.17	3	.03	4	.04	4	.04	4	.04	4	.04	4	.04	4	.04
2400	Agitators, Mixers and Blenders	.1	24	.02	5	.01	2	0.00	2	0.00	2	0.00	2	0.00	2	0.00	2	0.00
2600	Hoppers, Bins, Chutes and Silos	1.2	16	.19	7	.08	6	.07	6	.07	6	.07	6	.07	6	.07	6	.07
2700	Classification/Screening Equip.	.5	17	.09	7	.04	6	.03	6	.03	6	.03	6	.03	6	.03	6	.03
2800	Other Major Equipment	.4	16	.06	7	.03	6	.02	6	.02	6	.02	6	.02	6	.02	6	.02
2900	Environment/Process Vent Equip.	1.2	16	.19	3	.04	4	.05	4	.05	4	.05	4	.05	4	.05	4	.05
3200	Launders and Sumps	1.0	17	.17	8	.08	8	.08	7	.07	7	.07	7	.07	7	.07	7	.07
3300	Thickeners/Thickening Mech.	.5	17	.09	8	.04	8	.04	7	.04	7	.04	7	.04	7	.04	7	.04
3400	Roasters, Ovens, Dryers/Kilns	.7	17	.12	8	.04	8	.06	7	.05	7	.05	7	.05	7	.05	7	.05
	Total Major Equipment	19.4	17	3.26	6	1.24	6	1.10	6	1.19	6	1.25	6	1.25	6	1.25	6	1.25
4100	Concrete Work/Piling	4.9	24	1.18	4	.20	2	.10	6	.29	6	.29	6	.29	6	.29	6	.29
4200	Pipe, Valves/Fittings - Aboveground	3.0	44	1 32	3	.09	3	.09	7	.21	7	.21	7	.21	7	.21	7	.21
4300	Structural Steel	6.8	28	1.90	3	.20	0	0.00	6	.41	5	.34	5	.34	5	.34	5	.34
4400	Instruments and Controls	1.0	20	.20	5	.05	7	.07	7	.07	7	.07	7	.07	7	.07	7	.07
4500	Painting	.2	12	.02	5	.01	6	01	5	.01	6	.01	5	.01	5	.01	5	.01
4600	Electrical	7.0	32	2.24	3	.21	5	.35	5	.35	5	.35	5	.35	5	.35	5	.35
4700	Insulation	.1	20	.02	5	.01	6	.01	5	.01	6	.01	5	.01	5	.01	5	.01
4800	Roads, Parking, Paving, RR/Fences	2.5	16	.40	5	.13	3	.08	5	.13	5	.13	5	.13	5	.13	5	.13
4900	Buildings	1.6	16	.26	5	.08	3	.05	5	.08	5	.08	5	.08	5	.08	5	.08
	Total Bulk Materials	27.1	28	7.54	4	.98	3	.76	6	1.56	5	1.49	5	1.49	5	1.49	5	1.49
	Field Labour	18.0	10	1.80	9	1.62	8	1.44	9	1.62	9	1.62	9	1.62	9	1.62	9	1.62
	Field Costs	23.5	8	1.88	7	1.65	7	1.65	7	1.65	7	1.65	7	1.65	7	1.65	7	1.65
	Total Construction	88.0	16	14.48	6	5.49	6	4.95	7	6.02	7	6.01	7	6.01	7	6.01	7	6.01
	Home Office and Overhead	12.0	10	1.20	12	1.44	6	.72	8	.96	8	96	8	96	8	.96	8	.96
	Total Plant Cost*	100.0	16	15.68	7	6.93	6	5.67	7	6.98	7	6.97	7	6.97	7	6.97	7	6.97

* Excluding Fee

NOTES: 1. The rates of escalation for years 1978 through 1982 reflect our opinion as to what may happen. As trends develop, these figures will be adjusted.

SOURCE: Ralph M. Parsons Company (Lavalin Consulting Engineers, Montreal)

TABLE 3-9

Table of Actual and Forecast Escalation Rates for a Particular Item

Account Name	Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1000 - Hoists and Cranes	1973	100.0	101.3	102.7	104.0	105.3	106.7	108.0	109.3	110.7	112.0	113.3	114.7
	1974	116.0	117.9	119.9	121.8	123.7	125.7	127.6	129.5	131.5	133.4	135.3	137.3
	1975	139.2	139.9	140.6	141.3	142.0	142.7	143.4	144.1	144.8	145.5	146.2	146.9
	1976	147.6	148.3	149.0	149.8	150.5	151.2	152.0	152.7	153.5	154.2	154.9	155.7
	1977	156.4	157.2	158.0	158.8	159.5	160.3	161.1	161.9	162.7	163.4	164.2	165.0
	1978	165.8	166.5	167.2	167.9	168.6	169.2	169.9	170.6	171.3	172.0	172.7	173.4
	1979	174.1	174.8	175.5	176.3	177.0	177.7	178.4	179.2	179.9	180.6	181.3	182.1
	1980	182.8	183.5	184.3	185.1	185.8	186.6	187.4	188.1	188.9	189.6	190.4	191.2
	1981	191.9	192.7	193.5	194.3	195.1	195.9	196.7	197.5	198.3	199.1	199.9	200.7
	1982	201.5	202.4	203.2	204.0	204.9	205.7	206.6	207.4	208.2	209.1	209.9	210.8
	1983	211.6	212.5	213.4	214.2	215.1	216.0	216.9	217.8	218.6	219.5	220.4	221.3

Source: Ralph M. Parsons Company (Lavalin Consulting Engineers, Montreal)

Index for 1000 Account July 1975 = 143.4

Index for 1000 Account October 1980 = 189.6

$$\text{Multiplier} = \frac{189.6}{143.4} = 1.3221$$

Escalation Percent = (1.3221 - 1) x 100 = 32.2%

The arithmetic average differs from the weighted average in the following manner. To illustrate this, consider Table 3-8 for 1973.

Ex. 1 Weighted Average

Total Basic Cost = 19,400

Wtd. Escalation = 3.26

Revised Cost = 19,400 (1.0326) = 20,032

Arithmetic Average

Total Basic Cost = 19,400

Escalation as Pct. = 17.3

Revised Cost = 19,400 (1.173) = 22,756

The above two examples give results differing by more than 12 percent with the arithmetic average on the high side.

This example clearly shows why the weighted average is used for packages with many items possessing different escalation rates. Clearly, when items have large differences in their pct. of total cost and in their escalation rate percentage, the arithmetic average will give a distorted outcome.

However, some contracts still maintain the use of the arithmetic average method. The following pages will show the continuation of typical contract clauses.

Material Escalation Calculation

Symbols used in this Clause shall have the following meanings:

(1) APM (Amount of present price representing material) = material content of price as listed in Appendix I - Schedule of Bid Information.

(2) MBI (Material Base Index) = *

(3) MAR (Material Actual Rate) = *

Changes in present prices resulting from escalation of material shall be = APM times $\frac{MAR - MBI}{MBI}$.

For material the Material Actual Rate (MAR) will be the arithmetic average of the specified monthly index over a three-month interval. Price changes will be calculated at three-month intervals and will be applied to payments for work completed during such intervals. Payments due because of escalation will be made when the specific indices become available.

Shop Labour Escalation Calculation

Symbols used in this Clause shall have the following meanings:

(1) APS (amount of present price representing shop labour) = shop labour content of price as listed in Appendix I - Schedule of Bid Information.

(2) SBI (Shop Labour Base Index) = *

(3) SAR (Shop Labour Actual Rate) = *

Changes in present prices resulting from escalation of shop labour shall be = APS times $\frac{SAR - SBI}{SBI}$.

For shop labour the Shop Labour Actual Rate (SAR) will be the arithmetic average of the specified monthly index over a three-month interval. Price changes will be calculated at three-month intervals and will be applied to payments for work completed during such intervals. Payments due because of escalation will be made when the specified indices become available.

Site Labour Escalation Calculation

Symbols used in this clause shall have the following meanings:

(1) APL (Amount of present price representing Site labour) = Site labour content of price as listed in Appendix I of Schedule of Bid Information.

(2) LBI (Site Labour Base Index) = the Total Wages for each month calculated from the wages including payroll overhead entered in Appendix II of the Schedule of Bid Information

in accordance with Contractor's Collective Labour Agreements, and the proposed number of manhours to be worked at Site entered in Schedule of Bid Information.

(3) LAR (Site Labour Actual Rate) = the Total Wages for each month calculated from the wages including payroll overhead based on Contractor's Collective Labour Agreements in force at time escalation is calculated and the same number of manhours as for LBI.

Changes in present prices resulting from escalation of Site Labour shall be = APL times $\frac{LAR - LBI}{LBI}$.

Price changes resulting from escalation of Site Labour will be calculated and take effect on the date that new wage rates come into effect in accordance with Contractor's Collective Labour Agreements. Price changes will be calculated monthly thereafter and included in the Contractor's progress payments.

Escalation for Local Labour and Materials

Escalation for Local Labour and Materials will be calculated by using the following formula:

$$EL = PL \left[\left(a \times \frac{CA}{CO} + b \frac{SA}{SO} + c \times \frac{PA}{PO} + d \times \frac{TA}{TO} + e \times \frac{EA}{EO} + f \times \frac{LA}{LO}\right) - 1 \right]$$

In which:

EL = Adjustment to the Contract Price, calculated for an Escalation Period.

PL = The total local currency component of the tendered contract value of the Work executed during the Escalation Period, as recorded on the interim certificates issued by the Engineer, increased by the local currency component of advance payments for Constructional Plant and decreased by repayment of such advances, as specified in Clause 3.5 of Special Conditions.

CA = Cost Index of Cement

CO = Base Index of Cement

SA = Cost Index of Steel

SO = Base Index of Steel

PA = Cost Index of Petroleum Products

PO = Base Index of Petroleum Products

TA = Cost Index of Lumber

TO = Base Index of Lumber

EA = Cost Index of Explosives

EO = Base Index of Explosives

LA = Cost Index of Labour

LO = Base Index of Labour

a, b, c, etc. = are percentages for material and labour portions of total price.

Escalation for Foreign Labour and Materials

Escalation for Foreign Labour and Materials will be calculated by using the following formula for each type of foreign currency quoted in the Tender:

$$EF = PF \left[\left(a \times \frac{CA}{CO} + b \times \frac{SA}{SO} + c \times \frac{FA}{FO} + d \times \frac{GA}{GO} + e \times \frac{EA}{EO} + f \times \frac{LA}{LO} + g \times \frac{KA}{KO} \right) - 1 \right]$$

In which:

EF = Adjustment to the Contract Price, calculated for an Escalation Period.

PF = The total currency component for a foreign currency before adjustment of the tendered contract value of the work executed during the Escalation Period, as recorded on the interim certificate issued by the Engineer, increased by said foreign currency component of advance payments for Constructional Plant and decreased by repayment of such advances in that currency as specified.

CA = Cost Index for Cement

CO = Base Index for Cement

SA = Cost Index for Steel

SO = Base Index for Steel

FA = Cost Index for Constructional Plant and Spare Parts other than tires

FO = Base Index for Constructional Plant and Spare Parts other than tires

GA = Cost Index for Tires

GO = Base Index for Tires

EA = Cost Index for Explosives

EO = Base Index for Explosives

LA = Cost Index for Salaries of expatriate staff

LO = Base Index for Salaries of expatriate staff

KA = Cost Index for Shipping

KO = Base Index for Shipping

End of contract clause quote.

SUMMARY

The above all represent price adjustment practices in accordance with price adjustment formulae in light of changes in labour and material price indices after the date of the original quotation. These formulae are not intended for use in forecasting.

It should be noted that these formulae vary somewhat in their use throughout the world. The formulae used in the United States are similar to those mentioned and are outlined on the following page.

In the United States the generally accepted formula is as follows:[13]

U.S.A.

Quoted Prices - Usually subject to escalation.

Type of escalation formula - $EP = OP\ (a\ M_2/M_1 + b\ L_2/L_1)$

where

[illegible]scalated price

OP = Original quoted price

M2 = Material wholesale price index (four digit industrial class) (published monthly by Bureau of Labour Statistics), at date of shipment.

M1 = Similar index at date of quotation

L2 = Average hourly earnings (standard industrial code) (published monthly by Bureau of Labour Statistics), at date of shipment.

L1 = Similar index at date of quotation.

a and b are percentages for material and labour portions of total price.

Buying out of escalation - Possible, but very expensive (can be up to 20%) and not recommended as alternate to open escalation with formula.

3.6 FORECASTING ESCALATION RATES

The preparation of an escalation index or escalation rate over a specific time period is no simple task. There is a dichotomy between the mathematical approach and the purely intuitive method that many believe to be just as accurate. The optimal approach is a combination of the two. Most companies and firms do not possess the resources to prepare analyses of trend and cyclical seasonal and irregular variations in order to compute their own indices. Consequently, most firms rely on indices published by select groups which are made available to the public. The kind of assumptions made in preparing these forecast rates deal with such matters as percentage wage increases in the light of government policy and union activity; the effect of currency fluctuations on materials prices; the level of optimism in the industry, and the estimated extent to which tenderers will pass on increases in costs in their tender rates.

There is one particular analytical method of determining escalation indices that analyzes costs as being dependent on a number of factors. Costs for a building are influenced by such factors as the building size, number of floors, location, quality, market conditions and many more. The difficulty is in determining exactly what factors cause variations in costs and in what proportions. In this regard, various models have been examined by Isotalo[34]. The actual construction costs of various building types were compared with those obtained using each of the models and the standard deviation of the difference between actual and estimated escalation rates were found. The results were as follows:

Model	Standard deviation (%)
Building costs per m^2	12.5
Building costs per m^2 with elimination of local cost differences	11.7
Simple model with four variables and elimination of local cost differences	10.0
Loan evaluation model with 120 variables (Swedish Ministry of Housing)	6.3

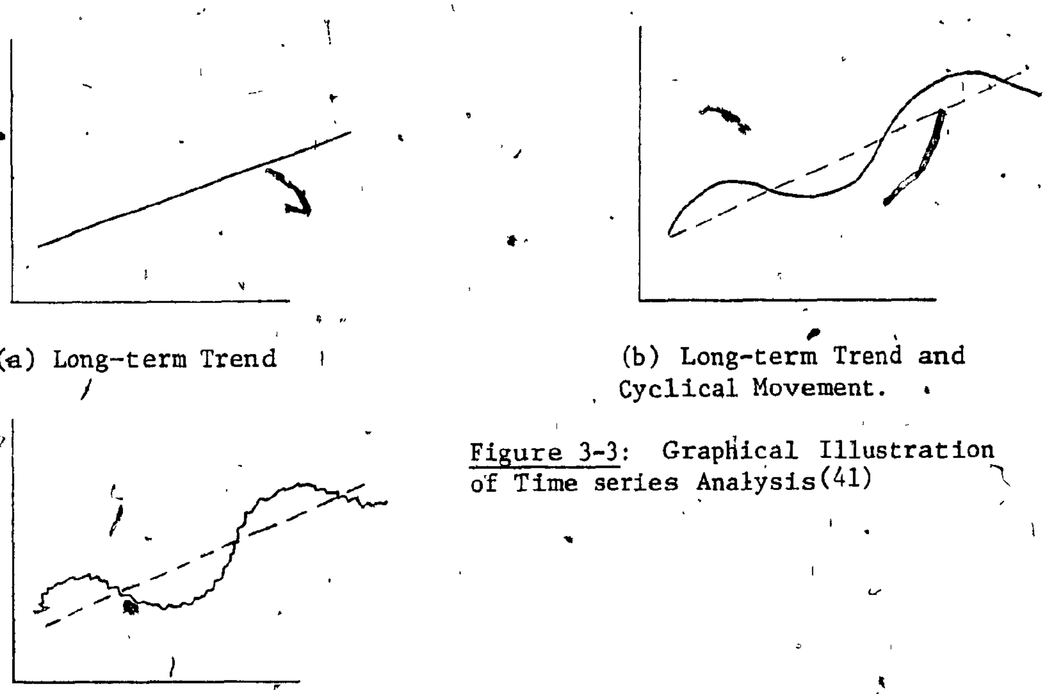
A simple observation of the above indicates that the most successful predictive model is the one containing the most variables. The most common mathematical approach in the statistical interpretation of factors used in determining indices is "Regression Analysis". The technique used is based on the premise that if sufficient data are gathered for two or more variables, it may be possible to derive an equation which relates these variables in a consistent way. The simplest form of regression analysis occurs where there are only two variables and they may be graphed against one another. The trend of the points on a graph may be approximated by a curve that gives the best fit. This curve represents the approximate relationship between the two variables. If the two variables are denoted as x and y and the curve allows us to estimate y from x, then it is called the regression curve of y on x. Problems involving more than two variables can be treated in an analogous manner. If, however, the number of variables exceeds three, geometric intuition is lost and groups of simultaneous equations must be solved in order to relate the variables.

By using derived equations, indices could be constructed for individual projects or for project types on a local, national or international basis. The difficulty of compiling these indices over a period of say, longer than one year, is the non-stability of the effect of the variables and in some cases for variables such as exchange rate fluctuations, updating would be ideal on a minimum monthly basis. The use of multiple regression analysis in index construction has increased management knowledge about the importance of certain variables in determining particular costs. Many firms who produce indices today follow a procedure similar to that discussed above.

Another method for cost index determination is the analysis of the "Time Series". A time series is a set of observations taken at specific times, usually at equal intervals. In a time series a variable, usually called y, is a function of time, t. ($y = f(t)$). A cost index is therefore a time series. By analyzing a time series of historic data, forecasts about the future can be made. Experience gained in such techniques has revealed that there are certain characteristic movements or variations in a time series, some or all of which may be present in varying degrees. These components may be classified into four types: long term or secular movements, cyclical movements, seasonal movements and irregular or random movements.

Long term or secular movements (T) refer to the general trend of the time series. If a graph is drawn of the time series, a "trend line" can be fitted to it. This trend line best approximates the general direction of the plotted data. This is similar to the previously described procedure adopted for regression analysis with two variables. A trend line is usually shown as a straight line, as in Figure 3-3, although it may also be curved.

Cyclical movements or variations (C) refer to long-term oscillations or swings about a trend line or curve. An important example of cyclical movement is the "business cycles", representing intervals of prosperity, recession, depression and recovery. All of these parameters have an important influence on the construction industry. Cyclical movements can be regarded as such if they occur at intervals of greater than one year.



(a) Long-term Trend

(b) Long-term Trend and Cyclical Movement.

(c) Long-term Trend, Cyclical and Seasonal Movement

Figure 3-3: Graphical Illustration of Time series Analysis(41)

Seasonal movements (S) refer to the almost identical patterns which a time series appears to follow from year to year such as a jump in escalation every January first as the terms of wage agreements are fulfilled. Seasonal movements may also occur over shorter periods and even weekly movements may be regarded as seasonal.

Irregular or random movements (I) refer to sporadic differentials of the time series resulting from chance events such as strikes and increases in the price of energy. If the time series (Y) is regarded as a product of the four components described, then, (Y) may be described by an additive or multiplicative model of the variables T, C, S and I, i.e., Y = T + C + S + I or Y = T x C x S x I, whichever works better. Analysis of a time series involves isolation of each of these factors and is often referred to as a decomposition of a time series. Apart from the freehand method of curve fitting described previously there are various mathematical techniques for estimation of trends. Cyclical, seasonal and irregular patterns may be eliminated by using moving averages of appropriate orders. Moving averages are arithmetic means of groups of months which give a new index series when calculated sequentially. Moving averages have the property that they tend to smooth out the amount of variation in a set of data. By adjusting the size of the groups of months averaged, different variations can be smoothed out. The use of moving and other averages allows the isolation by turns of each of the variables T, C, S and I.

It must, however, be realized that the mathematical treatment of data to determine indices is not in itself complete. Judgement, ingenuity, common sense and experience coupled with appropriate use of available economic forecasts (such as those produced by the Bank of Canada and Statistics Canada) remain invaluable supplements to such mathematical analysis. The preceeding description of the two mathematical methods is brief but illustrates the methods involved.

CHAPTER 4

CONTINGENCY AND ESCALATION

4.1 INTRODUCTION

Until now, contingency and escalation have been treated separately. In reality, one cannot be regarded without due consideration of the other with respect to any project estimate. The above statement holds, if for no other reason, because contingency takes into account fluctuations in the estimated escalation rate and escalation is applied to the sum of direct costs and contingency.

Basically the cost control of a project, which deals with both funds simultaneously warrants a concurrent understanding of the means by which the basic cost estimate was formulated and the methods used in the project life cycle forecast for both contingency and escalation.

In order to effectively monitor a project as construction proceeds, it is necessary to analyze both contingency and escalation as well as direct costs. Often, through poor management control and lack of experience on the part of management staff, contingency and escalation appropriations are treated as open ended funds from which sufficient funds may be attained to cover cost overruns in the direct cost accounts. This is a misuse of these funds and frequently, if not always, creates major difficulties for both the project manager and the owner. The following example will attempt to clarify the procedure for analyzing costs with time and uncertainty.

In this chapter, we shall describe calculations involved in utilizing contingency and escalation analysis in conjunction with a budget monitoring system.

4.2 SAMPLE CALCULATION CONSIDERING CONTINGENCY AND ESCALATION

Let's assume for illustrative purposes that the estimated cost of a conveyor system (CS) is $300,000 in July 1978 dollars. The uncertainty for this equipment has been determined to warrant a contingency allocation of 15 percent and escalation has been calculated to be 10 percent per year compounded. The scheduled equipment delivery date is July 1980; two years hence.

The following contingency rate shall apply to these examples:

Condition	Contingency (percent)
Completed items	0
Committed items	5
Estimated items	15

Case 1

If a purchase order is written for the CS in January 1979, for $430,000 and the price is firm for delivery; what is the impact on the estimate? In this case the contingency shall be 5 percent since the uncertainty in the estimate decreases after the purchase order has been written.

Case 2

If the purchase order is written for the CS in January 1979 for $340,000 but the price is subject to escalation from the date of the purchase order at 8% per year compounded to the scheduled delivery date of July 1980. What is the impact on the estimate? Again, the contingency shall be 5 percent since the purchase order has been written.

Figure 4-1 shows the calculations which are performed for the contingency and escalation analysis in Case 1.

For this example and that of Case 2, the calculations are straightforward and do not require any sophisticated mathematical techniques or computer assistance. However, on large projects, the control of costs is much more involved as has been shown in Parts 2 and 3. These examples serve strictly to illustrate the interrelationship between contingency and escalation.

The results of the analysis for Case 1 allow a comparison of budgeted and committed costs in order to determine the appropriate cost forecast. Figure 4-2 shows that this procedure can also be used to incorporate different escalation rates and different periods for escalation.

FIGURE 4-1

Contingency and Escalation Analysis - Case 1

(1)	Budget Dollars	= Total Direct Cost Estimated in the Initial Budget
(2)	Budget Contingency	= (Budget Dollars) x (Applicable Contingency Rate for This Item)
(3)	Budget Escalation	= (Budget Dollars + Budget Contingency) x (Applicable Escalation Rate Compounded to This Item's Delivery Date from the Base Date of the Initial Estimate)

FIGURE 4-1 (Cont'd)

Therefore,

(1)	Conveyor System (CS) Budget Dollars	= $300,000
(2)	CS Budget Contingency = ($300,000) x (.15)	= 45,000
(3)	CS Budget Escalation = ($300,000 + $45,000) x (.21) where 21% is the Escalation Rate at 10% per Year Compounded for Two Years	= 72,450
	Total Budget Costs	$417,450

Then,

(4)	Committed Dollars	= Dollar Amount of Equipment Purchase Order
(5)	Committed Contingency	= (Committed Dollars) x (Applicable Contingency Rate for This Item). Note: This Contingency Rate will usually be different from the Rate for the Budget Item due to different uncertainties.
(6)	Committed Escalation	= _0_ for Firm Price Purchase Order
		= (Committed Dollars + Committed Contingency) x (Applicable Escalation Rate Compounded to this Item's Delivery Date from the Base Date of the Purchase Order). Note: The Escalation Rate and the Period of Escalation will usually be different from the Budgeted Rate and Period of Escalation.

Thus,

(4)	CS Committed Dollars	= $430,000
(5)	CS Committed Contingency = ($430,000) x (0.05)	$ 21,500
(6)	CS Committed Escalation = Firm Price	_0_
	Total Committed Costs	$451,500

By comparing the Total Budgeted Costs ($417,450) to the Total Committed Costs ($451,500), the impact on the budget of an increase of $37,050 can readily be determined.

Note: Committed Dollars is the dollar value at the time the purchase order is written.

Source: Criteria for Analyzing Contingency and Escalation, R. Cook, AACE Trans. 1978.

FIGURE 4-2

Contingency and Escalation Analysis - Case 2

(1), (2) and (3) The Total Budgeted Dollars are the same as in Case 1 or $417,450

However,

(4)	CS Committed Dollars	= $340,000
(5)	CS Committed Contingency = ($340,000) x (.05)	= $ 17,000
(6)	CS Committed Escalation = ($340,000 + $17,000) x (.122) where 12.2% is the Escalation Rate at 8% per Year Compounded for 1-1/2 years	= $ 43,550
	Total Committed Costs	$400,550

By comparing the Total Budgeted Costs ($417,450) to the Total Committed Costs ($400,550) the impact on the budget of a decrease of $16,000 can readily be determined.

Source: Criteria for Analyzing Contingency and Escalation, R. Cook, AACE Trans. 1978.

It may be beneficial to further clarify the distinction between contingency and escalation analysis versus usage. The procedure presented here provides a specific, detailed method for calculating revised estimates for contingency and escalation whenever new information indicates that re-evaluation is necessary.

After contingency and escalation estimates are revised, a comparison of the budgeted values and the latest forecast values will yield the net effect on the project estimate. The result may also indicate that contingency has been reduced (or increased) by some dollar amount. This change is due to a change in uncertainty as no contingency has been used to cover cost variances in the direct accounts. As indicated in Figure 4-1, contingency was used to offset all or any part of the direct cost increase but escalation was not. These items were re-evaluated based upon new information.

The combined change of the direct costs and the re-evaluation of contingencies and escalation provides the overall impact of the cost variances. These indirect accounts were re-evaluated because of new information pertaining to committment, i.e., purchase order (because of firm quote, reduction in contingency is because of committment and escalation changes with time frame), not because the direct costs increased (or decreased). For example, if the uncertainty had not changed in Figure 4-1, the initial contingencies would have increased by \$19,500 to \$64,500 (\$430,000 x 0.15) and the budget impact would have been increased by \$77,050 instead of \$37,050. Thus, it should be evident that contingency is not "used" to cover cost overruns in the direct accounts but is increased or decreased only, due to changes in uncertainty. Normally, the uncertainty of the items in the estimate continually decreases with a corresponding increase in information about these uncertainties. However, the decrease in contingency is not dependent on any cost changes in the direct accounts but due to a firming of the information (i.e. a purchase order).

The same philosophy is true for escalation. In Figure 4-2, escalation costs changed because the rate and period to apply escalation changed - not because the direct costs were revised. If, in fact, the rate and period had remained unchanged, escalation would have increased by $2,500 to $74,970 ($357,000 x 0.21) instead of decreasing. Again, it is evident that these costs were revised in Figure 4-2 due to new information. The following Table 4-1 summarizes the results of these computations.

TABLE 4-1

Summary of Example Calculations

Case	Direct Cost	Contingency	Escalation	Total Costs
Estimate (Budget Cost)	300,000	45,000	72,450	417,450
Case 1 (Committed Cost)	430,000	21,500	0	451,500
Case 2 (Committed Cost)	340,000	17,000	43,550	400,550

4.3 CONCLUSION

As a project proceeds along its life cycle, it is essential to analyze and re-forecast contingency and escalation as well as direct costs. The above procedure allows for an orderly method of analyzing all project costs with time.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The paper has attempted to point out the importance of basic definitions and proper application and control of contingency and escalation. No estimator or manager should be dealing with escalation and contingency on large projects without possessing some fundamental knowledge about these two important aspects of large projects.

It is the intent of the writer that the information gathered and presented in this paper should be of prime importance to those individuals who work for developers, consultants or any other non-contracting construction organization. Although the paper was not written from the contractors point of view, contractors and their representatives should find it to be a worthwhile reference document.

5.2 RECOMMENDATIONS

In any subject or field, there is always room for improvement or further study. Contingency and escalation have recently become subjects of great concern in project life cycle estimating because of projects both large in cost and duration. However, there is some lack of knowledge on the part of owners and consultants regarding how to estimate and control contingency and escalation allowances such that a proper budget may be established and maintained.

During the course of this paper, no study was found dealing with the post mortum analysis of a project whereby the final contingency was determined per activity and then compared to the original estimated activity. If such analyses were carried out by major consultants both they, and other companies with access to their data, would benefit because of the ability to establish more accurate contingency allowances, thereby achieving more accurate cost estimates.

Escalation is easier to manage than contingency, since the use of specific available indices permits simple arithmetic calculations to determine the escalation allowance. However, it is recommended that knowledgeable persons select the appropriate index or better still, combination of indices for a particular project.

The monitoring of escalation and contingency is not easily done on a large project that has a duration of years. The use of computer programs enables the quick updating of costs over specified time periods. However, little work has been done to incorporate into programs the capability of periodic contingency and escalation adjustments and monitoring.

Large consultants and owners would probably benefit immensely from the use of a computer program enabling them to monitor and adjust contingency and escalation.

More research could be done on making practical analytical methods to calculate contingency available to estimators. Many analytical methods are long and tedious and might warrant computer assistance for their quick determination.

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