Chapter 12
Construction Payment/Cost

12.1 Introduction

Price and payment are important provisions in every construction contract. Contractors, subcontractors, and suppliers all require a certain amount of cash to finance their ongoing operations. For this reason, payment terms usually are spelled out in great detail in construction contracts. The interrelation between time and money is always of major importance to both the Owner and the General Contractor.

In order to complete a project on schedule, the Contractor must have sufficient cash flow. In the construction industry, funds flow from the Owner to the General Contractor and hence to the subcontractors and suppliers, based on satisfactory work done. This means that each Contractor must be paid promptly, within the terms of the contract for the work performed within the payment period specified. Therefore, it is essential that progress payments, as well as payments for additional work ordered by the Owner, be quickly processed to maintain the Contractor's cash flow. It is also important that claims for additional payment be quickly resolved to avoid a project delay.

The Owner also has to make sure that the payments made against work done and changes made shall not cross the required project budget. For this reason, the Owner must establish a sound cost monitoring and controlling system. This chapter addresses the provisions and issues regarding payments made against work done, changes, holdback, and controlling project cost.

12.2 Contract Price

The contract price is defined in CCDC-2 [1] as the amount stipulated in Article A-4 of the agreement. In FIDIC Conditions of Contract [2], the contract price is considered as the amount accepted in the Letter of Acceptance and any adjustments which

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are provided for in the contract. In fact, under FIDIC Conditions of Contract [2], the contract price is distinguished from the accepted contract amount.

The contract price is the sum identified for provision of the entirety of the works. It is not assured that the Contractor will get that amount upon completion. Additions and alterations are part of most contracts which will, of course, change the contract price. There are provisions laid out in most of the contracts on how these changes are to be evaluated in terms of cost.

12.3 Progress Payments

Progress payments to the Contractor are usually made on monthly basis as the work proceeds. CCDC-2 [1] Sub-clause 5.2.1 provides that an application for payment may be made monthly as the work progresses. As discussed in Chap. 2, CCDC-2 [1] Sub-clause 5.3.1.3 further provides that the Owner shall make progress payment to the Contractor on or before 20 calendar days after the Consultant's receipt of the Contractor's application for payment or the last day of the monthly payment period.

Similarly, FIDIC Conditions of Contract [2] also provides under Sub-clause14.3 that the Contractor shall submit the application for interim payment certificate after the end of each month. As discussed in Chap. 2, FIDIC Conditions of Contract [2], clause 14.7(b), further provides that the Employer shall make interim progress payments within 56 days after the Engineer receives the Contractor's statement and supporting documents.

The Contractor submits his interim valuation, based on the current work done and cost of material delivered to site, which is then evaluated and certified by the Engineer. For unit price contracts, the payment is made according to the unit rates for work carried out. For lump sum contracts, interim payments are made on a percentage basis for work done in that month. Whereas, cost-plus contracts usually provide for the Contractor to submit interim payment at specified intervals during the life of the contract. Sometimes mistakes happen in recording measurements and payments are issued based on those incorrect measurements. Thus it is advisable to add a provision in the contract specifying that, "The Contract Administrator may correct any error in an interim certificate in subsequent certificates."

Some contracts specify minimum amounts for interim payment; hence, the Contractor has to submit his interim payment when he crosses or reaches that figure. While evaluating the interim valuation of the Contractor, if the amount due to the Contractor is less than the minimum amount stated in the contract, no certificate is issued and the payment is included in the following certificate. Before certifying the payment, some deductions are made from each interim payment like previous payments, holdback/retention money (usually 10% of the total work done), and any government tax (if applicable). The holdback money is one of the securities held by the Owner to ensure fulfillment by the Contractor of his obligations under the contract.

In order to have the contracting and subcontracting system function smoothly, delay in payment must be avoided. As per CCDC-2 [1], if the Consultant fails to issue a payment certificate or the Owner fails to pay the Contractor due certified amounts within the specified time as mentioned above, then the Contractor may give notice in writing to the Owner that the Owner is in default of his contractual obligations and to advise him to correct the default within 5 working days (Sub-clause 7.2.4); otherwise the Contractor may suspend or terminate the contract.

Similarly, as per FIDIC Conditions of Contract [2], if the Employer fails to issue a payment within the specified time as mentioned above, then Sub-clause 16.1 provides that the Contractor may give 21 days' notice and then suspend or reduce the rate of work. Additionally, under Sub- clause 16.2(c), the Contractor is entitled to terminate the contract if payment is not received within 42 days of the due date.

12.4 Final Payments

Acceptance of the project and final payment by the Owner must proceed in accordance with the terms of the contract.

12.4.1 Procedures Under FIDIC Conditions of Contract

As per FIDIC [2] Sub-clause 10.1, when the Contractor feels the works are completed in accordance with the contract and will be ready to be taken over by the Employer within 14 days, he can give such notice to the Engineer. The Engineer within 28 days shall issue the taking-over certificate to the Contractor, indicating the completion date except for any minor outstanding work or defects, provided that they do not substantially affect the use of the works for their intended purpose.

After receiving the taking-over certificate, the Contractor (within 84 days) shall submit to the Engineer a statement at completion (Sub-clause 14.10) with supporting documents, in respect of the whole of the works, showing in detail the final value of total work done, including further sums which the Contractor considers to be due and an estimate of amounts, which the Contractor considers will become due to him under contract. The Engineer within 28 days of receiving the statement of completion should certify to the Owner the amount of payment to the Contractor, which he considers due and payable at that time.

Thereafter, once the Contractor rectifies the defects within the defects' liability period, the Engineer shall issue the performance certificate (Sub-clause 11.9) within 28 days if he is satisfied that the Contractor has fulfilled his obligations during the defects' notification period. Within 56 days after receiving the performance certifi-

cate, the Contractor can submit an application for the final payment certificate (Sub-clause 14.11) with supporting documents, showing in detail the value of total work done in accordance with the contract and any further sums if due. While evaluating, if the Engineer has any comments or needs further information, the Contractor should attend to that requirements and resubmit his final statement/valuation.

However, if there are still differences of opinion which need time to resolve, the Engineer should issue a further interim certificate for the portion of work not in dispute, such that the Contractor can finalize the requirements of that portion. As soon as the dispute is resolved and the Contractor and Engineer agree on the basis of final statement, Sub-clause 14.12 requires that the Contractor should give a written discharge to the Employer with copy to the Engineer, confirming the total settlement of all monies due to him as per contract. Such discharge, however, shall become effective once the final payment has been made and the performance security is returned to the Contractor.

After receiving the final statement and Contractor's written discharge, the Engineer should within 28 days issue a final certificate for payment to the Employer, which in the opinion of the Engineer is due under the contract.

12.4.2 Procedures Under CCDC-2 and Related Canadian Documents

As per clause 5.4 of CCDC-2 [1], when the Contractor has determined that the works are substantially performed (as defined in the construction Lien Act [3]), he can give such notice within 1 working day to the Consultant and Owner including a list of items to be completed or rectified. Upon verifying that the contract has been substantially performed, the Consultant within 20 calendar days shall issue a copy of that certificate to the Owner and the Contractor with the date on which the works were substantially performed. However, if the Consultant identifies some deficiencies in the work, a list of all such deficiencies or uncompleted work will be issued to the Contractor for correction and completion before issuing the certificate of substantial performance.

After receiving a copy of substantial performance certificate, the Contractor shall publish a copy of the certificate in a construction trade newspaper as required under Section 32(1) of the Construction Lien Act [3]. As per Section 31 of the Act, the day following the date of publication shall be the date of commencement of the required 45-day period to release the basic statutory holdback monies. The holdback monies are defined in Chap. 1.

According to the Ontario Provincial Standards (OPS.MUNI 100) [4], when the Consultant issues the certificate of substantial performance, he should also issue the substantial performance payment certificate and the substantial performance statutory holdback release payment certificate which shall include:

1. The value of work performed to the date of substantial performance

2. The value of outstanding or incomplete work
3. The amount of the statutory holdback, allowing for any previous releases of statutory holdback to the Contractor in respect of completed subcontracts and deliveries of preselected equipment
4. The amount of maintenance security required
5. The amount due the Contractor

The payment of the amount certified shall be made within 30 days of the date of issue of the payment certificate except the basic holdback. The basic holdback shall be released after the expiry of the 45-day period as mentioned above but on submission of the following documents as required under Ontario Provincial Standards (OPS.MUNI 100) [4]:

1. Proof of publication of the certificate of substantial performance
2. A certificate of clearance from the Workplace Safety and Insurance Board,
3. A statutory declaration (CCDC- 9A [5]) to state that all liabilities incurred by the Contractor and the Contractor's subcontractors in carrying out the contract have been discharged except for amounts properly retained as a holdback or as identified in any dispute of payments
4. A release by the contractor in a form satisfactory to the Consultant releasing the Owner from all further claims relating to the contract

For final payment, CCDC-2 [1] under clause 5.7 provides that when the Contractor considers that the work is completed, he shall submit an application for final payment. The Consultant, within 10 calendar days shall review the work and, if satisfied that the work is completed in accordance with the contract, shall promptly issue a final certificate for payment except the finishing holdback. As per Ontario Provincial Standards (OPS.MUNI 100) [4], the final payment certificate shall show:

1. Measurement and value of work at completion
2. Invoice for finishing holdback
3. The amount due to the Contractor

Like basic holdback, the finishing holdback shall also be released after the expiry of 45 days from the completion date but on submission of the following documents as required under Ontario Provincial Standards (OPS.MUNI 100) [4]:

1. A written statement by the Contractor (in a form satisfactory to the consultant) releasing the Owner from all further claims relating to the contract
2. A certificate of clearance from the workplace safety and insurance board
3. A statutory declaration CCDC- 9A [5] to state that all liabilities incurred by the Contractor and the Contractor's subcontractors in carrying out the contract have been discharged

Once the Consultant verifies that no liens have been preserved, the finishing holdback is released 1 day after termination of the 45-day period.

The procedures for substantial performance and completion take-over of projects are further explained in more detail in document Number-100 published by Ontario

Association of Architects (OAA) and Ontario General Contractors Association (OGCA) [6].

12.5 Cash Allowances and Contingencies

12.5.1 Cash Allowances

Cash allowances also known as provisional sums for materials or work are added in the schedule of prices or bill of quantities when it is not possible to clearly define the scope of that material or work at the time of bid, e.g., allowance for removal and disposal of asbestos containing materials. Cash allowances must be stated in the Contract Documents and shall be expended as the Owner directs through the Consultant.

As per clause 4.1 of CCDC-2 [1], the contract price includes all cash allowances and in connection with such cash allowances, the contract price, and not the cash allowances, includes the contractor's overhead and profit. Hence, no markup shall be added to any payment made under the cash allowances as it is already covered under the bid price. The value of work performed is included in the progress payments.

FIDIC Conditions of Contract [2] defines "provisional sum" as a sum specified in the contract for the execution of any part of the works or for the supply of plant, material, or services. Sub-clause 13.5 specifies that the Contractor shall be paid for the actual amount used for the work or material and a sum for overhead charges and profit. The provisional sums should only be used for the works as specified in the contract and in accordance with the Engineer's instructions.

12.5.2 Contingency Allowance

A contingency allowance is used for any unforeseen work or costs that may, or may not, ultimately be required. Expenditures from a contingency allowance are administered in the same way as extra cost change orders under the contract. Under Subclause 4.2.2, CCDC-2 [1] provides that the contingency allowance includes the Contractor's overhead and profit on expenditures from the contingency allowance. Hence, markup shall be added to any payment made under contingency allowance.

Cost contingencies provide reserves against risk of cost increases during the development of the project. The initial magnitude of the contingencies on any project depends upon many factors, and based on that, contingencies can be established as a specific amount or as a percentage of a budget estimate. The contingencies should be used only on the written instructions of the Consultant to supplement the budget of those operations which have been identified necessary.

12.6 Changes in the Work

The change or variation in work can be defined as changes made in the design, quality, or quantity of the original scope of work set out in the contract. Ontario Provincial Standards [4] defines changes as deletion, extension, increase, decrease, or alteration of lines, grades, dimensions, quantities, methods, drawings, substantial changes in geotechnical, subsurface, surface, or other conditions; changes in the character of work to be done, or materials of the work or part thereof, within the intended scope of the work.

In any construction project, changes to the base scope of work are almost always required as the construction proceeds on site. Most changes are not the result of some fault on the part of a party to the project; they are due to the complexities of construction, unforeseen conditions, changes required by the Owner or the Consultant may need to issue additional information as the work proceeds.

Most of the forms of contract include a clause enabling the Owner to instruct changes in the base scope of the work. As per CCDC-2 [1] clause-6, the Owner, through the Consultant can make changes in the work for any additions, deletions, or other revisions including changes to the contract time by issuing a change order or change directive. It further provides that the Contractor shall not perform a change in the work without having a change order or change directive.

Change order is defined in CCDC-2 [1] as a written amendment to the contract prepared by the Consultant and signed by the Owner and the Contractor stating their agreement upon a change in the work including any adjustment if required to the contract price or contract time. Whereas a change directive is a written instruction prepared by the Consultant and signed by the Owner directing the Contractor to proceed with a change in the work within the base scope of the contract prior to the agreement on any adjustments to contract price or contract time between the Owner and the Contractor.

Similarly clause-13 of FIDIC Conditions of Contract [2] covers the provisions for making changes in the work. However, FIDIC Form allows the Engineer but not the Employer to issue directions to change the works. Each change may include:

(a) Changes in the quantities of any work in the contract
(b) Changes to the quality and other characteristic of any such work
(c) Changes to the levels, positions, and dimensions of any part of the works
(d) Omission of any work under the contract
(e) Any additional work, plant, material, or services necessary for the completion of the works
(f) Changes to the sequence or timing of construction of any part

It further provides that the Contractor shall not perform a change in the work unless and until the Engineer instructs or approves a change.

Per the change provisions of the contract, the Owner and Consultant can amend the works as and when required necessary. In the absence of such a clause, it would be difficult to make some amendments required in the work, and any attempt by the

Owner to initiate changes would technically require a new agreement with the Contractor. The main purpose of the change provisions is to allow such changes to be carried out so as to complete the project smoothly. However, in general, the Owner should not make large scale or significant changes to the nature of the work and beyond the scope of the original contract altogether as it will require a separate contract.

12.6.1 Dealing with Changes

Dealing with changes in a timely and efficiently manner will benefit both the Owner and the Contractor. The early settlement of changes minimizes cost to owners and saves contractors from delaying the project.

Under Sub-clause 6.2, CCDC-2 [1] suggests that when a change in the work is required, the Consultant shall provide the Contractor with a written description of the required work. The Contractor then promptly shall submit the estimate and method for the proposed work with any change in contract price and contract time if required. When Owner and Contractor agree on the submitted quotation, a change order is issued to the Contractor and the contract price is updated accordingly. If the price quoted by the Contractor is not reasonable, then the parties need to negotiate the price with an intention to reach an acceptable price. The value of work performed on the basis of change order is claimed through a progress payment.

The Contractor's request for any change to the scope of work must be consistent with the contract, or it will likely be denied. The Contractor should make changes only when he gets written instructions from the Consultant. If the Contractor acts without an instruction, he will have no grounds to claim for the cost of such change. In order to deal with changes properly, all parties need to be familiar with the contract documents, particularly the conditions covering changes and extras, completion and time extensions, liabilities, and warranties.

Parties to the contract should avoid such actions or inactions which may give rise to a claim, such as the Owner shall avoid delayed approval of Contractor submissions, late design changes, delay in supply of items on behalf of the Owner, failure to coordinate work of third parties, errors or inadequacy of the Contract Documents, and so on. Similarly, the Contractor must assure that the contractual requirements for submittals, reports, and other supporting documentation are met in a timely fashion as the work progresses.

12.6.2 Valuation of Changes/Variations

When a change order for variation is agreed to be issued, the changed or extra work needs to be valued. The rules for valuation of variations suggested in most of the standard forms of contract can be summarized as under:

(a) Where the varied work is of a similar character and executed under similar conditions, the rates and prices set out in the contract should be used to value variations.
(b) Where the varied work is same in character but is executed under different conditions, the rates and prices in the contract shall be used as the basis for valuation, known as pro-rata basis.
(c) If the varied work is different and does not meet above two requirements, then a fair method of valuation is to be used and agreed by all parties, accounting for direct cost, impact cost, and markup (indirect cost or overhead plus profit) as defined in following pages.

For estimating fair value of extra or additional works, the following information could be helpful:

1. For rent of equipment, OPSS127 [7] – schedule of rental rates for construction equipment can be used.
2. For labor rates, statistics Canada provides monthly wages rates for construction union and nonunion workers.
3. Unit prices can also be considered from historical data in previous bids.
4. "Hanscomb Yardsticks for Costing [8]" is also very useful which provides item rates based on every province in Canada.

In the event of disagreement, the Engineer as specified under clause 12.3 of FIDIC [2] shall fix such rates or prices as fairly as possible and in consultation with both parties and notify the Contractor accordingly with a copy to the Employer. Until the rates or prices are agreed or fixed, the Engineer may determine provisional rates or prices so that the Contractor should get his interim payment based on such work done.

12.6.2.1 Time and Material

If the varied work cannot be properly measured or valued, then the Contractor is to be paid for the work done on time and material (T&M) bases. It may be noted that a decision for this method should be made by the Consultant, who should issue such instructions; it is not for the Contractor to insist on valuation according to T&M basis. Payment per this method is calculated based on actual cost of labor hours, material, and equipment used as explained in Chap. 5.

The Contractor should furnish to the Consultant on daily basis the daily work record showing the hours spent on the work, the worker names, plant and equipment employed on the work, and details of material used.

12.7 Construction Cost Control

Different cost terms are used while estimating and controlling project costs, some of those are:

- *Variable costs*: costs that vary or change with the amount of production or the amount of work done. Examples are materials, supplies, and wages.
- *Fixed costs*: costs that do not change with the change in production. The examples are set up cost, rental equipment, or machinery costs.
- *Direct costs*: operating costs except markup (overhead plus profit). Examples are labor, material, plant and equipment, small tools, subcontractor's cost, and testing.
- *Indirect costs*: costs related to head office expenditures. Examples are management and engineering, supervision and inspection [9], insurance and bonds, building rent/utilities, phones, computers, interest and taxes, and other office petty expenses.
- *Impact costs*: costs that are the indirect results or consequences of a change. Examples are disruptions, inefficiencies, delays, accelerations, premium time, remobilization, idle labor, and equipment.

For cost control on a project, the construction plan and the final cost estimate provides a baseline for the assessment of financial performance during the project. For control and monitoring purposes, the original detailed cost estimate is typically converted to a project budget, and the project budget is used subsequently as a guide for management.

For effective cost control, it is important that all three resource parameters – time, cost, and performance – must be analyzed as a group. To be within budget serves no useful purpose if performance is poor. An effective control system monitors schedule and performance as well as cost, measuring expenditures against budgets and identifying variance, assuring that the expenditures are proper and taking corrective action when required. Cost control is a process that should be continued throughout the construction period to ensure that the cost of the project is kept within the agreed cost limits.

An important part of cost control is to calculate the variance, its magnitude and to decide if the variance requires corrective action. There are several cost reporting and controlling systems such as project cost-value reconciliation, overall profit or loss, actual versus forecast reconciliation, earned value analysis, etc.; however, here we will discuss "earned value" reporting system which is the most commonly used method of performance evaluation and project cost control. This reporting system combines performance, time, and budget. The earned value technique measures actual performance of the progress on a project and enables monitoring of both cost and schedule variance.

When using earned value technique (EVT), the following definitions need to be understood:

- *Earned value (EV)*: EV is the budgeted amount for the actual work done within the specified time, i.e., the amount of progress payments (usually monthly) submitted by the contractors.

- *Planned value (PV)*: PV is the planned budgeted cost, required for the work to be done within the specified time. This is calculated on a monthly basis from the baseline schedule of the project. The total amount of activities to be done per month is calculated and recorded to compare it with the monthly progress payments submitted by the Contractor, i.e., the EV.
- *Actual cost (AC)*: AC is the total cost actually paid for the work done within the specified time. This is in fact the actual cost of the activities performed by the Contractor.
- *Cost variance (CV)*: CV is equal to earned value minus actual cost:

  $CV = EV - AC$ and $CV\% = CV / EV \times 100$

- *Schedule variance (SV)*: SV is equal to earned value minus planned value:

  $SV = EV - PV$ and $SV\% = SV / EV \times 100$

- *Cost performance index (CPI)*: CPI is a measure of cost efficiency. It measures the value of work performed against the actual cost.

  CPI = EV / AC. If above 1, it is considered under budget; if below 1, it is over budget.

- *Schedule performance index (SPI)*: SPI is a measure of schedule efficiency. It measures the value of work performed against the actual cost.

  SPI = EV/PV. If above 1, it is considered ahead of schedule; if below 1, it is behind schedule.

Now to understand EVT for a project, two activities are shown in Table 12.1.

As per activity of Raft Foundation, earned value EV is less than planned value PV, which indicates that the project is behind schedule, whereas the activity of superstructure shows EV is higher than PV, which indicates that the project is ahead of the schedule.

It further shows that AC for Raft Foundation is higher than EV, which means that expenditure is more than the earned value (EV) which indicates that the project is over budget. On the other hand, AC for superstructure is less than the EV which shows that the project is within budget. Similarly the table also shows values for CPI and SPI. For Raft Foundation, CPI is 0.93, which is below 1; that means the activity is over budget. For superstructure, CPI is 1.15, which is above 1 meaning the activity is under budget. Similarly for Raft Foundation, SPI is 0.92, which means it is behind schedule, whereas for superstructure the SPI value is 1.10, which means above 1: hence, it is ahead of schedule.

The negative variance for Raft Foundation clearly indicates that there is a loss; hence, corrective measures are immediately required. The positive variance is an encouraging sign that indicates that amount of work done at the specified time is more than the work planned on that time; hence, the project is ahead of the schedule.

Table 12.1 Example of cost and schedule variance

Performance report sample									
	Budget	Earned value	Actual cost	Cost variance		Schedule variance		CPI	SPI
WBS element	PV ($)	EV ($)	AC ($)	EV−AC ($)	CV/EV (%)	EV−PV ($)	SV/PV (%)	EV/AC	EV/PV
Raft foundation	63,000.00	58,000.00	62,500.00	−4,500.00	−7.75	−5,000.00	−7.90	0.93	0.92
Super structure	200,000.00	220,000.00	190,000.00	30,000.00	13.00	20,000.00	10.00	1.15	1.10

WBS = Work breakdown structure

12.8 Forecasting

Forecasting is also one of the tools to monitor and control costs. Earned value technique also provides formulae to forecast the future performance of the project.

EAC: Estimate at Completion The expected total cost of completing project work.

It is the forecasted cost of the project as the project progresses. There are different methods to determine EAC; however, in its most commonly used form, it is the budget at completion (BAC) divided by the cost performance index (CPI), i.e.,

EAC = BAC / CPI (BAC is the original total budget allocated to the project).

This method is used when we assume that future work will continue at the present cost performance index, meaning the change encountered by the project is typical.

Other methods for calculating EAC include:

EAC = AC + ETC. This is called a "bottom-up" formula.
EAC = AC + (BAC − EV). This method is used when the project has encountered a one-time (atypical) change.

ETC: Estimate to Complete The estimated cost of completing the remaining work.

ETC is a forecast of how much more money will need to be spent to complete the project.

There are primarily two methods of calculating ETC:

ETC = (BAC − EV)/CPI

Similar to EAC method, this method is used when we consider that future work will continue at the present cost performance index, meaning the change encountered by the project is typical.

ETC = EAC – AC. This method is used when we have calculated EAC.

Simple Example 12.1
Now as a simple example to understand difference between EAC and ETC, let us consider the activity of Raft Foundation within Table 12.1 above; we will have:

EAC = BAC / CPI = $63,000.00 / 0.93 = $67,741.93 (overall estimate on completion)
ETC = (BAC − EV) / CPI = ($63,000.00–$58,000.00) / 0.93 = $5376.34 (estimate for remaining amount to complete the project).

Once we know EAC and ETC, we can calculate variance at completion (VAC).

VAC is the difference between the original project cost (baseline) and what it is currently expected to cost.

VAC = BAC − EAC = $63,000.00 − $67,741.93 = −$4741.93

Negative variance indicates over budget, meaning the project lost money.

12.9 Value Engineering

Value engineering is one of many cost-saving techniques. It is an organized approach to identify and eliminate unnecessary costs. It helps with elimination or modification of anything that adds cost to an item without contributing to its required functions. During this process, all expenditures relating to design, construction, maintenance, operation, replacement, etc. are considered.

Under value engineering, the functions of a product or service or project activity are analyzed in order to reduce the overall cost, to determine "best value" or the best relationship between worth and cost, without sacrificing quality or performance requirements. It usually involves steps of gathering required information, searching for creative ideas, evaluating suitable alternatives, and proposing cost-effective alternatives. The major objective of value engineering as applied to construction projects is to reduce initial and life cycle costs.

At the planning and design stage, designers design one or more systems to satisfy the requirements and then select a system for value analysis. Next, the designers should question whether the system chosen provides the best value at the lowest cost. Value engineering is a useful procedure for answering this question and selecting a better alternative if the answer indicates this is desirable. At the planning and design level, value engineering is mostly done in four stages:

1. *Information gathering stage*: This stage involves in identifying the main elements of a product, service, or project and analyzing the functions of those elements. Function analysis, an important technique in value engineering, is usually done in this stage. At this stage, key criteria and objectives for the project are defined. The objective of information gathering is to determine what functions or performance characteristics are important. Questions need to be asked like: What is the purpose of the project? What should it provide? What should it not include? And so on.
2. *Alternative generation stage*: In this stage, alternative solutions are developed for delivering necessary functions. Various alternative ways of meeting requirements are created and reviewed for additional ideas that would perform the desired function.
3. *Analysis stage*: In this stage, all the alternatives are assessed by evaluating how well they meet the required functions and how successfully expenditure is minimized. Ideas found to be impractical are discarded. Ideas with greatest potential for cost savings and value improvement are considered.
4. *Decision stage*: In the final stage, each recommendation is presented with a brief narrative to compare their advantages and disadvantages. Wherever required, sketches and design calculations are included in this stage along with cost comparison and life cycle cost calculations. Finally, the best alternative is to be chosen and proposed to the Owner.

The value engineering efforts should be initiated at the early stages of project design because early review results in greater savings and allows a change of direc-

tion, if appropriate, without affecting project delivery schedules. Note that substantive change in later stages incurs more costs to parties involved due to duplicated work or rework.

During the construction phase, contractors are often required to suggest changes in the plans or specifications and to share in the resulting savings. These changes may involve substitution of materials, modification of design, reduction in quantities, or procedures other than those set forth and required by the Contract Documents. Value engineering is designed to take advantage of the Contractor's special knowledge and to cut the cost of a project to the lowest practicable level without compromising its function or sacrificing quality or reliability. In short, the Contractor is encouraged to develop and submit to the Owner cost-reducing proposals leading to changes in the plans or specifications. If the proposals are accepted by the Owner, a change order/variation is processed, and the savings are usually shared equally by the Owner and the Contractor. Contractors are willing to examine such alternatives when offered incentives for sharing the savings by the Owner.

Another form of cost savings from value engineering is the expertise of Contractor's site staff to take advantage of such techniques which affect the cost of various activities/items/functions performed without sacrificing quality. For example, the depth of a strip footing is 300 mm, whereas the depth of most of the floor beams is 450 mm; hence, it is advisable to order formwork of 450 mm, so as to reuse the same formwork in foundations as well as throughout the upper floors. Similarly, using steel formwork can provide cost saving with a multistory building instead of wooden formwork. The wooden formwork may lose its strength after reuse four or five times, whereas steel formwork will remain mainly unaffected.

Another example could be use of precast staircases instead of cast in situ, in a high-rise building. With a precast staircase, there will be more saving by cutting the cost of reusing formwork, excessive manpower, steel fixing, and concreting process throughout in the upper floors of a high-rise building. In such a way during construction, a sensible Construction Manager can reduce the overall cost of the project and increase his profit by utilizing his expertise by proposing various alternatives in performing construction activities.

12.10 Life Cycle Costing (LCC)

Life cycle costing or whole life costing is also one of the cost control and cost awareness techniques which takes into account the total cost, both present and future. It can be defined as an economic evaluation technique that involves the assessment of the total cost of an asset over its operating life, including initial capital costs, maintenance costs, operating costs, and the cost or benefit of the disposal of the asset at the end of its life.

The LCC analysis assists funding decisions by highlighting the total cost of an asset over the course of its life expectancy, rather than focusing on initial construction costs only. It can also be used to compare investment alternatives with different

initial and future costs. For example, for an infrastructure asset it can be used to compare construction and material costs of asphalt pavement versus concrete pavement including assessment of future cost of operating, maintaining, rehabilitating, and replacing an asset.

The major benefits of LCC analysis can be summarized as:

1. Improves awareness of total costs
2. Gives a picture of true total costs
3. Identifies choice of alternative courses of action
4. Identifies those areas where costs may be reduced
5. Allows to arrange for future funds

A clear understanding of life cycle phases for a project permits managers and executives to better control total corporate resources in the achievements of desired goals. The life cycle phases of a project may include:

(a) *Initiating or conceptual phase*: This includes the preliminary evaluation of an idea with assessment of the technical and financial viability of the project. The most important component in this phase is a preliminary analysis of risk and resulting impact on the time, cost, and performance requirements, together with a potential impact on company resources.
(b) *Planning or definition phase*: This phase includes identification of work to be done with initial preparation of all documents like schedule of works, quality control procedures, etc. This phase indicates planning methods that are applicable and provides the basis for controlling an operation in order to reach an established goal. It includes appointment of the design team and other consultants, establishment of budget including cash flow, identification of the appropriate contract strategy, and determining bidding procedures and select Contractor.
(c) *Construction or production phase*: It includes executing, controlling, and closing processes. It involves monitoring of progress and expenditure, direction and inspection of works, certification of payments, checking safety and quality control systems, approval of variations, holding of progress meetings, and problem resolution.

    Finally, during closing process, this phase includes issuing of completion certificates, ensuring correction of deficiencies, ensuring final accounts are settled, arranging As-Built drawings, commissioning, and handing over.
(d) *Operational phase*: This includes the operational life of the project and provides evaluation of the technical, social, and economic sufficiency of the project to meet actual operating conditions.
(e) *Divestment phase*: It includes disposal, termination, or replacement of the project.

Once the life cycle phases of the project are identified and understood, the cost breakdown structure (CBS) is prepared. The aim is that the whole life cost model should include every cost likely to be incurred in respect of the project from inception to disposal. The CBS represents the way LCCs are broken down and presented.

Each cost element within the CBS must be well defined so that all involved have a clear understanding of what is to be included in that element. The CBS should be designed to allow different levels of data within various cost categories according to their functionality. After the production of a CBS, costs for each category are calculated. Cost estimates are usually made up of the base estimate and risk allowance.

Reference and Further Reading

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