# Techno India NJR Institute of Technology


## Course File

## Project Planning and Construction Management lab (8CE4-21)

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# RAJASTHAN TECHNICAL UNIVERSITY, KOTA

**Syllabus**

## IV Year-VIII Semester: B. Tech. (Civil Engineering)

**8CE4-21**: Project Planning and Construction Management Lab

**Credit 1** **Max. Marks: 50(IA: 30, ETE: 20)**
**0L+0T+2P**

1. Assignments on net present value, benefit cost ratio, internal rate of return
2. Types of contracts – Tenders, tender form, submission and opening of tenders, measurement book, muster roll, piecework agreement and work order.
3. Drafting of tender documents, special terms and conditions
4. Drafting of tender notices for different types of works
5. Different models of PPP like BOT, BOOT etc.
6. Arbitration
7. Preparation of bar diagram
8. Network Analysis using PERT and CPM

**Course Overview:**

Student will learn basics of PPCM from these 40 hours course. It introduces the basic learning requirements for the civil engineer project manager and makes the appreciation for the qualitative nature of the construction project management. The philosophy of the course is more on system approach contrary to majority of mechanics-based subject. Also, need for construction industry has been emphasized.

**Course Outcomes:**

| CO.NO. | Cognitive Level | Course Outcome |
|---|---|---|
| 1 | Comprehension | Students will be able to understand construction risk management, the roles and responsibilities of all constituencies involved in the design and construction process. |
| 2 | Comprehension | Students will be able to understand concept of ne work analysis CPM and PERT methods and network rules and regulations |
| 3 | Synthesis | Students will be able to design a network diagram to create the project schedules, Critical path, slack in between activities using CPM & PERT techniques. |
| 4 | Comprehension | Students will be able to Identify the project cost and time control using network techniques. |
| 5 | Analysis | Students be able to Analyze about the contract management. |

**Prerequisites:**

- Students will be able to compute construction risk management and identify the roles and responsibilities of all constituencies involved in the design and constructionprocess.
- Students will be able to understand concept of network analysis CPM and PERT methods and network rules and regulations
- Students will be able to design a network diagram to determine the duration of project, Critical path, slack in between activities using CPM & PERT techniques/
- dents will be able to analyze the project cost and time controlling network techniques

## Course Outcome Mapping with Program Outcome:

| Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO421.1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| CO422.2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 1 |
| CO423.3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 |
| CO424.4 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 1 |
| CO425.5 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 1 |
| CO425 (AVG) | 2.4 | 2 | 2 | 2 | 1.8 | 1.6 | 1.6 | 1 | 2 | 1.8 | 2 | 1.4 | 2 | 1.6 | 1 |

## Course Coverage Module Wise:

Unit Topic

1. Assignment on Net present value, benefit cost ratio, internal rate of return,
2. Risk cost management, main causes of project failure.
3. Types of tenders, Tender forms, Submission and Opening of tenders
4. Measurement book, Muster roll, Piece work agreement and work order.
5. Drafting of tender documents and special terms and conditions
6. Drafting of tender notices of different types of works
7. Assignments on Arbitration
8. Concept of Network Analysis Using PERT and CPM
9. Solved numerical based on CPM and PERT.

## TEXT/REFERENCE BOOKS


1. Project management with CPM/PERT by B.C. Punmia, Laxmi Publication (P) Ltd.
2. Construction Project Management by K.K Chitkara, Tata Mc Graw Hills.
3. Project Management by Modder & Phillph, CBS Publishers.
4. Project Planning and Control by Punmia and Khandelwal K.K., Laxmi Publication (P) Ltd.
5. Project Management by Choudhary S., Tata McGraw Hill Publishing Company Limited, NewDelhi

## Assessment Methodology:

1. Practical exam using Geotech
2. Internal exams and Viva Conduct.
3. Final Exam (practical paper)

**TEACHING AND LEARNING RESOURCES UNIT-WISE:**

1. **FINANCIAL EVALUATION OF PROJECTS AND PROJECT PLANNING**

**Video Tutorials:**

https://nptel.ac.in/courses/105/104/105104161/

https://nptel.ac.in/courses/110/104/110104073/

https://drive.google.com/drive/folders/19nJ_FMwWjvaFvGaoelrtNCklGrHXaAX2

**Theory concepts:**

https://drive.google.com/drive/folders/10lSi6iQ3ReHDUL-6_Oy1h7jzKuiwxDlA

https://drive.google.com/drive/folders/13WBog5benU3wAJ5lsyNRITyoYE_JJBP0

**Sample Quiz:**

https://global.oup.com/us/companion.websites/9780199397150/student/chapter14/multiplechoice/

2. **PROJECT SCHEDULING**:

**VideoTutorials:**

https://nptel.ac.in/courses/105/104/105104161/

https://drive.google.com/drive/folders/19nJ_FMwWjvaFvGaoelrtNCklGrHXaAX2

**Theory concepts:**

https://drive.google.com/drive/folders/10lSi6iQ3ReHDUL-6_Oy1h7jzKuiwxDlA

https://drive.google.com/drive/folders/13WBog5benU3wAJ5lsyNRITyoYE_JJBP0

https://www.interventions.org/pertcpm.html

**Sample Quiz:**

https://www.vskills.in/practice/cpm-pert-test https://www.courseya.com/pert-and-cpm-mcq/

## 3. PROJECT COST AND TIME CONTROL

**VideoTutorials:**

https://nptel.ac.in/courses/105/104/105104161/

https://drive.google.com/drive/folders/19nJ_FMwWjvaFvGaoelrtNCklGrHXaAX2

**Theory concepts:**

https://drive.google.com/drive/folders/10lSi6iQ3ReHDUL-6_Oy1h7jzKuiwxDlA

https://drive.google.com/drive/folders/13WBog5benU3wAJ5lsyNRITyoYE_JJBP0

https://www.interventions.org/pertcpm.html

**Sample Quiz:**

https://www.vskills.in/practice/cpm- pert-test https://www.courseya.com/pert-and- cpm-mcq/

## CONTRACT MANAGEMENT & SAFETY AND OTHER ASPECTS OF CONSTRUCTION

https://drive.google.com/drive/folders/10lSi6iQ3ReHDUL-6_Oy1h7jzKuiwxDlA

https://drive.google.com/drive/folders/13WBog5benU3wAJ5lsyNRITyoYE_JJBP0

https://drive.google.com/drive/folders/19nJ_FMwWjvaFvGaoelrtNCklGrHXaAX2

https://nptel.ac.in/courses/105/103/105103093/

https://nptel.ac.in/courses/105/104/105104161/ nline-quiz/

**Introduction**

We have introduced discounted cash flow analysis. We will examine investment criteria for selecting a project (i.e., formulae): Net Present Value (NPV), Benefit-Cost Ratio (B/C ratio), Internal Rate of Return (IRR) and for projects of unequal length (i.e., Equivalent Annual Net Benefits and Common Multiples of Duration).

**Net Present Value Criterion**

The Net Present Value (NPV) criterion is the principal government investment project evaluation criterion. The cash flows consist of a mixture of costs and benefits occurring over time. Net present value is merely the algebraic difference between discounted benefits and discounted costs as they occur over time. (You must think of the terms Anet present value@ and Anet present benefits@ as being interchangeable.) The formula for NPV is:

$$NPV = \frac{B_0 - C_0}{(1+i)^0} + \frac{B_1 - C_1}{(1+i)^1} + \ldots + \frac{B_T - C_T}{(1+i)^T}$$

Where: NPV, t = year, B = benefits, C = cost, i=discount rate.

Two sample problem:

Problem #1) NPV; road repair project; 5 yrs.; i = 4% (real discount rates, constant dollars)

| year = | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Benefits | $0 | 1200 | 1200 | 1200 | 1200 |
| - Cost | $3000 | 0 | 0 | 500 | 0 |
| B-C | $-3000 | 1200 | 1200 | 700 | 1200 |
| Disc. Factor | 1.04^1=1.04 | 1.04^2=1.082 | 1.04^3=1.125 | 1.04^4=1.169 | 1.04^5=1.217 |
| Disc. Annual Cash Flows | -$2884.61 | 1109.06 | 1066.67 | 601.89 | 986.03 |

Sum NPV = $879.04. Q: Go or no go? A: a single project with a positive NPV is a Ago.@

Problem #2) NPV, 5 yrs; i = 7.8%. Begins in time = 0.

| Year= | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Benefit | $0 | 2500 | 2500 | 2500 | 3000 | 3000 |
| Cost | $10,000 | 500 | 500 | 500 | 500 | 500 |
| Net | -$10,000 | 2000 | 2000 | 2000 | 2500 | 2500 |
| Disc. Factor | 1.078^0=1 | 1.078^1=1.078 | 1.078^2=1.162 | 1.078^3=1.253 | 1.078^4=1.35 | 1.078^5=1.45 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Disc Cash Flow | -$10,000 | 1855.28 | 1721.17 | 1596.17 | 1851.85 | 1724.14 |

Sum NPV = ($1125.39). Decision: Result is negative, hence no go.

**Benefit/Cost Ratio**

Most have heard of B/C ratio. Although not the preferred evaluation criterion, the B/C ratio does serve a useful purpose which we will discuss later. B/C formula:

$$B/C = [\frac{B_0}{(1+i)^0} + ... + \frac{B_T}{(1+i)^T}] \div [\frac{C_0}{(1+i)^0} + ... + \frac{C_T}{(1+i)^T}]$$

Problem #3) Plant grass to reclaim a strip mine site and use for livestock grazing. 5 year project, i = 10% , begin time 0.

| Year = | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Benefits | 0 | 0 | 0 | 0 | $5000 | 20000 |
| Disc Factor | 1.1^0=1 | 1.1^1=1.1 | 1.1^2=1.21 | 1.1^3= 1.331 | 1.1^4 = 1.464 | 1.1^5 = 1.61 |
| PVBen | 0 | 0 | 0 | 0 | $3415 | $12,422 |
| Cost | $6,000 | 4000 | 1000 | 1000 | 1000 | 1000 |
| PVC | $6,000 | 3636 | 826 | 763 | 683 | 621 |

Sum benefits = $15,837

Sum costs = $12,529

B/C ratio = $15,837/$12,529 = 1.26. Q: Go or no go? A: for a single project go. But we=ll say more on B/C ratio and multiple project comparisons later.

**Internal Rate of Return**

The IRR is used more for private sector projects, but it is important to know.

IRR is different than our other project evaluation criteria. In our previous formula, i was a known and we solved for the discounted cash flows. With IRR, i is the unknown. IRR is the annual earnings rate of the project.

To find IRR we want to know: Awhat is the discount rate (i) that will equate a time series of benefits and costs?@ Or, otherwise stated: PVB = PVC; or where PVB - PVC = 0

$$[\frac{B_0}{(1+i)^0} + ... + \frac{B_T}{(1+i)^T}] - [\frac{C_0}{(1+i)^0} + ... + \frac{C_T}{(1+i)^T}] = 0$$

or

$$[\frac{B_0}{(1+i)^0} + ... + \frac{B_T}{(1+i)^T}] = [\frac{C_0}{(1+i)^0} + ... + \frac{C_T}{(1+i)^T}]$$

Once the unknown Ai@ has been determined, you can compare i to the best available alternative rate of return. If the calculated i (IRR) is greater than the minimum acceptable rate of return (MARR) (i.e., you won=t accept an earning rate less than the MARR) then you will Ago@ with your project. Note: Calculated Ai@ = internal rate of return; MARR = external rate of return.
A word on computational difficulties: One problem with IRR is that it cannot be solved for in a direct algebraic fashion. Why? Recall from algebra, you need one equation for each unknown in order to solve. With IRR you have more unknowns than equations. Thus, you cannot solve for i. Hence, IRR must be solved for in iterative Atrial-and-error@ fashion.
Procedure for trial and error:
1) set-up your annual benefits and costs separately
2) put in an initial discount rate, discount all benefits and cost,
3) examine to see if B=C
4) if not, repeat calculations with a new discount rate,
5) repeat calculations with a new i until B–C (to first decimal place).
IRR Problem #4) We take a series of annual cash flows, begin with 7% discount rate:

| Year | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Cost | $85,000 | 5000 | 5000 | 5000 | 5000 |
| Disc Fact. | 1.07 | 1.14 | 1.22 | 1.31 | 1.4 |
| PVC | $79,439 | 4385 | 4098 | 3816 | 3571 |
| Benefits | $0 | 20000 | 25000 | 35000 | 50000 |
| PVB | $0 | 17534 | 20491 | 26717 | 35714 |

At 7% discount rate: sum PVB = $100456 - sum PVC = $95309 = $5147.
Decision: increase or decrease i? A; if B>C, the increase i and try again at 8% B-C = $2710. at 9% B-C = $586; at 9.3% benefits = costs, thus IRR = 9.3%
IRR is the annual earning rate of the project. Rule: accept project if IRR>MARR.

**Projects of Unequal Duration**

Thus far, we discussed projects without much discussion regarding the project duration.
The duration of projects is important, however, when you are comparing alternative projects. The rule: you cannot compare the NPVs of projects with unequal durations. You must make some adjustment for duration to make the comparable.
For example:
1) project A is 10 yrs. w/ NPV of $45,000; i=6%
2) project B is 15 years w/ NPV of $50,000; i=6%
Project B would seem to be the choice, but we cannot say because they are of unequal duration. You cannot compare projects of unequal service length.
Two Methods for Comparing Projects of Unequal Length:
1. EANB - compute equivalent annual net benefits (EANB). EANB restates NPV as a series of equivalent annual payments. It computes the amount needed to payoff a specified sum (NPV) in a series of equal periodic (e.g. annual) payments. Thus, 2 AEA projects@ are made comparable because their returns are annualized. The formula (NPV x Acapital recovery factor@):

$$EANB = NPV[\frac{i(1+i)^t}{(1+i)^t - 1}]$$

**Problem: 2** projects A&B.
A: project NPV =$45,000, t = 10, i = 6%
B: project NPV = $50,000, t = 15, i =6%
Question: which one should you undertake?
B seems better with higher NPV, but the 2 projects are of unequal length so you cannot compare just yet. You must use the EANB method. Work through this example. You will see that project A has the highest EANB, thus is the favored project.

2. Common Multiples of Project Duration: A second method of comparing projects of unequal duration is to compute the NPV using common multiples of project duration. Same problem:
1) project A is 10 yrs. w/ NPV of $45,000; i=6%
2) project B is 15 years w/ NPV of $50,000; i=6%
Steps:
1) find the common multiple in years of the 2 project lengths (in this case 30 years).
2) common multiple = 30 years. Thus 3-project As = 2-project Bs
3) for project A, the NPV of $45000 will cover the first 10 years. Another $45000 will be received 10 years hence, another $45000 is received 20 years hence. These 3 projects cover the 30 years.
4) Discount as follows:
Project A: NPV = $45,000 + $45,000/$(1.06)^{10}$ + $45,000/$(1.06)^{20}$ = $84,158
5) Project B NPV is $50,000 for first 15 years. Another $50,000 is received 15 years hence and this covers the last 15 years.
6) Discount:
Project B: NPV = $50,000 + $50,000$(1.06)^{15}$ = $70,863
Decision:
Project A: NPV = $84,158 > Project B: NPV = $70,863
Conclude: accept project A.
Q: are EANB and common multiples methods consistent? Yes, they are consistently in their ranking of projects.

# RISK COST MANAGEMENT, MAIN CAUSES OF PROJECT FAILURE.

## What is Cost Risk in Project Management?

Every project has a budget, and your job as the project manager is to make sure that the project stays within budget. Unfortunately, there is always the risk that a project will cost more than expected. This risk of not staying on budget is cost risk, and it comes with all projects. Some of the most common sources of project cost risks include:

- Poor budget planning
- Not calculating costs correctly
- Unexpected additions to the project (scope creep)

For a PMP, identifying cost risk is essential, but it's not easy. Because the consequence of not doing a thorough job identifying these types of risks can end up costing shareholders a lot of money, it is worth considering different types of cost risk to make identification easier. A thorough account of all the cost risks also puts the project manager (PMP) in a much better position regarding the establishment of a risk reserve.

## Types of Cost Risks

One way of distinguishing between types of cost risks is to consider the ability of the project manager to control them. Project Management Professionals (PMP) should know there are two types of cost risk related to this are internal and external types of cost risk. Some of these risks are avoidable; some are not.

## Internal Cost Risks

Internal costs risks stem from changes to the business or organization within which the project management team is working. Examples of internal cost risks may include additional project costs due to:

- Poor project budgeting practice
- Turnover of project management staff
- Project management technology problems that impact productivity

## External Cost Risks

External cost risks stem from circumstances beyond the control of the project management team; there isn't much a project manager can do to control them. For example, if your project uses a lot of gasoline as fuel for project equipment, you are at the mercy of those who control the cost of a barrel of oil. Examples of external cost risks may include additional project costs due to:

- Raw material costs
- Natural disasters
- Changes in regulations
- Increases in external vendor costs

## Direct and Indirect Cost Risks

Another dimension of cost risks is direct and indirect cost risks. These are not mutually exclusive with internal and external types; costs risks will be either internal or external, *and* either direct or indirect.

## Direct Cost Risks

Direct cost risks are those that are directly related to the project activities. Examples of costs resulting from direct cost risks could be:

- Rework to correct errors in construction
- Miscommunication that requires additional meetings

Indirect cost risks are those that are not directly related to project activities. Examples of costs resulting from indirect cost risk could be:

- Administrative cost for PMO resources
- Inventory storage
- Temporary housing accommodations for regulatory staff

**Additional Cost Risk Categories**

In addition to internal/external and direct/indirect cost risk categories, below are other cost risk categories that can help the project manager (PMP) and team discover cost risks they might otherwise miss. Again, these types are not mutually exclusive with the categories above. In fact, some of these are internal, some external, and some may include both; similarly, some of these are direct, some indirect, and some may include both.

**Operations Cost Risk**

Operational cost risks are the associated risks that come from sub-par operations on the project. Most operations-related cost risks are internal. Examples include:

- Inefficiencies when procuring project resources
- Poor quality management processes
- Redundancies with project communications.

**Input Cost Risk**

Input costs are those associated with the acquisition of required materials for construction of a product. Many of these are external and beyond the control of the project management team.

Mother Nature and global events are often sources of input cost risks. Examples of input cost risks include:

- War
- Sanctions
- Trade disputes
- A pandemic
- A shipping disruptions
- Labor disputes

A number of financial and market-related types of cost risk may include the following. These are generally external cost risks:

**Credit Risk**

Credit risk is the risk that your customers or partners will not pay you this may be external, although project managers (PMP) may be able to mitigate this risk through vetting of customers and partners and writing contracts to protect the project from this type of cost risk.

**Interest Rate Risk**

Interest rate risk is the risk that your cost of capital will go up due to rising interest rates. Projects

involving floating interest rates are more susceptible to interest rate risk. Those dealing with a fixed interest rate tend to be more stable and less volatile.

**Exchange Rate Risk**

If your project involves purchasing materials or labor overseas, you will have to account for exchange rate risk. This is the risk that exchange rates can suddenly become volatile and exceed what was budgeted. Large, global projects are most at risk of exchange rate risk.

**Legal and Compliance Risk**

Legal risk is the risk of penalties and fines or other project costs related to misunderstanding the laws governing your project. This type of risk increases when working internationally or when your project exposes you to different regional or state laws even within the same country. Certain fields can expose you to more legal and compliance risks. Projects in the health care industry in the United States, for example, require a thorough understanding of laws related to patient confidentiality regulations.

**Taxation Risk**

Projects are subject to taxes in the areas in which they are working, procuring, sourcing, etc. The risk of misunderstanding or interpreting taxation rules that impact the project may result in unforeseen costs to comply with the pertinent laws or penalties for failing to comply.

**When & How to Determine Cost Risks in a Project**

Traditionally, figuring out a project's cost risk involved analyzing schedule risk and subsequently analyzing cost risk. This can be problematic since the team members analyzing the schedule are concerned about the project being completed in a timely manner, and those analyzing the budget are concerned with the project being completed with as little cost as possible. These interests are often at odds with each other. This disconnect can complicate the risk analysis activities. In fact, this may add cost to the project by extending the time it takes to complete risk analysis, that is, create an operational cost risk.

A better way to analyze cost risk is to use an integrated approach. The sources of risk associated with a project are separated into those that affect time and those that affect cost, expressed as the burn rate per unit of time. The former is the schedule that the project runs on; the latter is how quickly it takes to spend money in a given amount of time.

Since time is money, costs will go up if a project takes longer than planned to complete. To determine cost risk in a project:

- Assess the various risks in the project
- Define, price, and assign resources to different activities
- Look at schedule (time) and cost (burn rate) risks simultaneously to develop estimates
- Use simulation programs such as Pertmaster or Monte Carlo for more accurate cost risk results

**Example of Cost Risk**

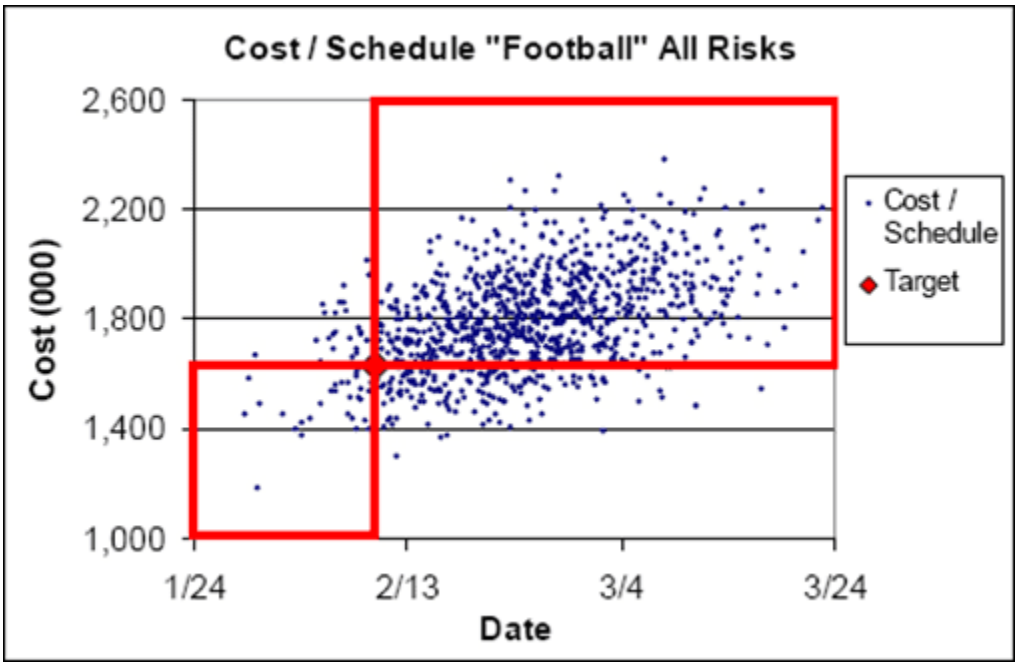
For a cost risk model with inputs, you would compare the number of people working on the project against pay rate and hours (see table below). An example of a common project many of

us have taken on is home renovations. As you're budgeting, you'll need to break up each part of the project into either time or burn rate.

| Cost Risk Model with Inputs | | | | |
|---|---|---|---|---|
| **Component 1** | Baseline Estimate | Low | Most Likely | High |
| Avg. Workers per day | 8.1 | 6 | 8 | 12 |
| Avg. Rate / Hour | 88.1 | 80 | 88 | 91 |
| Duration from Schedule | 98.0 | Est. Lognormal distribution | | |
| Component 1 Cost | 557 | | | |

Cost Risk Model with Inputs

If the schedule is simple, you can use Excel to create a scatterplot showing the relationship between cost and schedule. As you can see below, the longer something takes to do, the more it costs.




Cost / Schedule "Football" All Risks

As a Project Management Professional (PMP), your project doesn't need to be a billion-dollar global project to have multiple types of cost risk involved. We can use a simple project, like a home renovation project, to see how many types of cost risks are present in even small projects.

A few sources of project cost risks for a home renovation project may include:

- Securing permits (financial & compliance risk)
- Cost of the appliances (input cost risk)
- Delivery time for materials (operational risk)
- Taxes on house additions (taxation risk)

Don't forget about the indirect cost risks of renovating a house. Examples could include:

- Living in a hotel during the renovation
- Not getting rental income if you are renovating a rental property
- Food cost for takeout during renovation

**How to Mitigate Cost Risks**

Once meeting the challenge of identifying the various cost risks your project faces, it is critical to determine the appropriate response. Defining a risk reserve is essential to any response to project cost risk.

There are two types of risk reserves you'll want to build as you plan your project: management reserve and contingency reserve.

- **Management reserve:** This type of risk reserve is kept aside for unknown risks that may or may not happen during the project. Think of it as a buffer for the project. This risk reserve is usually set up by people who have more of a bird's eye view of the project and is not available to the project manager except with authorization.

**Contingency reserve:** This is a risk reserve for the known risks of the project. You can think about this type of risk reserve as insurance. An input to calculating this reserve may be done by multiplying the likelihood of each cost risk occurring by the financial consequence of each risk to the project. That is the expected monetary value (EMV) for each risk. Summing those EMVs for the project informs the project manager's recommendation for the contingency reserve.

Importantly, you will want to track when and how this risk reserve is used during the project's progress to know when to make adjustments and if the reserve will be sufficient. Note that the goal of the contingency reserve is not to cover cost overages 100% for every risk, but to make the project budget overage acceptable to the sponsor and key stakeholders. Tracking the risk contingency reserve is also a great tool for communicating with stakeholders about project status and progress. If you're using these types of risk reserves properly, it can protect your project and help manage stakeholder expectations.

**Conclusion**

While it is never possible to eliminate all risks, including cost risks, understanding the different types of costs risks can help identify them. Considering how important project cost typically is to the sponsor and key stakeholders, insight into these types of risks and strategies for mitigating them are central to effective project management. A risk management reserve and contingency reserve are the most common responses to project cost risks. As a project manager, understanding these risks and how to respond will increase your likelihood of finishing your project within budget, meeting your key stakeholders' definitions of success, and delivering value to your organization.

## Types of tenders, Tender forms, Submission and Opening of tenders

### 1. Open Tendering

Under open tendering the employer advertises his proposed project, and permits as many contractors as are interested to apply for tender documents. Sometimes he calls for a deposit from applicants, the deposit being returned 'on receipt of a bona fide tender'. However, this method can be said to be wasteful of contractors' resources since many may spend time preparing tenders to no effect. Also, knowing their chances of gaining the contract are small, contractors may not study the contract in detail to work out their minimum price, but simply quote a price that will be certain to bring them a profit if they win the contract. Thus the employer may be offered only 'a lottery of prices' and not necessarily the lowest price for which his project could be constructed. If he chooses the lowest tender he runs the risk the tenderer has not studied the contract sufficiently to appraise the risks involved; or the tenderer might not have the technical or financial resources to undertake the work successfully. It is true that the employer can check the resources and experience of the lowest bidder and reject his tender if the enquiry proves unsatisfactory; but several bids may be below the estimated cost of the job and, if such tenderers appear satisfactory and their bids are not far apart in value, it is difficult for the employer to choose other than the lowest. The engineer advising the employer may think there is a risk that all such low bids could prove unsatisfactory, but he cannot advise the employer what other bid to accept because he has no certainty of information.

### 2. Selective Tendering

Under selective tendering the employer advertises his project and invites contractors to apply to be placed on a selected list of contractors who will be invited to bid for the project. Contractors applying are given a list of information they should supply about themselves in order to 'pre-qualify'. The advantage to the employer is that he can select only those contractors, who have adequate experience, are financially sound, and have the resources and skills to do the work. Also, since only half a dozen or so contractors are selected, each contractor knows he has a reasonable chance of gaining the contract and therefore has an incentive to study the tender documents thoroughly and put forward his keenest price. However, since contractors have all pre-qualified it is difficult to reject the lowest bid, even if it appears dubiously low – unless that is due to some obvious mistake. A problem with both open and selective tendering is that a contractor's circumstances can change after he has submitted his tender. He can make losses on other contracts which affect his financial stability; or may be so successful at tendering that he does not have enough skilled staff or men to deal with all the work he wins. Neither method of tendering nor any other means of procuring works can therefore guarantee avoidance of troubles.

### 3. Negotiated Tendering

Negotiated tenders are obtained by the employer inviting a contractor of his choice to submit prices for a project. Usually this is for specialized work or when particular equipment is needed as an extension of existing works, or for further work following a previous contract. Sometimes negotiated tenders can be used when there is a very tight deadline, or emergency works are necessary. A negotiated tender has a good chance of being satisfactory because, more often than not, it is based on previous satisfactory working together by the employer and the contractor. When invited to tender the contractor submits his prices, and if there are any queries these are discussed and usually settled without difficulty. Thus mistakes in pricing can be reduced, so that both the engineer advising the employer and the contractor are confident that the job should be completed to budget if no unforeseen troubles arise. However, negotiated tenders for public works are rare because the standing rules of public authorities do not normally permit

them. But a private employer or company not subject to restraints such as those mentioned in the next section can always negotiate a contract, and many do so, particularly for small jobs. Even when a negotiated tender is adopted it is usual to prepare full contract documents so that the contract is on a sound basis. Production of the documents also means they are available for open or selective tendering should a negotiated tender fail, or should the chosen contractor be unable to undertake the work.

# CONSTRUCTION PLANNING & MANAGEMENT

## UNIT - 1

## PROJECT MANAGEMENT

- 'Project management' is required to deal with both 'material' as well as 'human factors' to increase the productivity.

**Objectives of a project :**

- It should be completed with minimum time with minimum capital investment.
- It should use available manpower and other resources optimally.

### PHASES OF PROJECT MANAGEMENT

**1. Planning :**

Planning involves

(i) Defining objectives of the project.

(ii) Listing of jobs that have to be performed.

(iii) Determining gross requirements for material, equipment and man power and preparing estimates of costs and duration for various jobs.

(iv) To bring about the satisfactory completion of project.

***Planning is important because***

(i) It provides direction and unifying frame work.

(ii) It helps to reveal future opportunities and provides performance standards.

(iii) It minimises costs by utilising available resources in best way.

**2. Scheduling**

Scheduling is the allocation of resources

*It involves :*

- Formalising the planned functions mechanically.
- Assigning starting and completion dates to each activity to proceed in logical sequence and systematic manner.

**3. Controlling**

*Controlling includes :*

(i) Determination of deviations from basic plan and their effects on the plan.

(ii) Replanning and rescheduling of activities to compensate for the deviations which is called "updating".

- It should be noted planning and scheduling are accomplished before the actual project starts while controlling is operative during execution of the project.

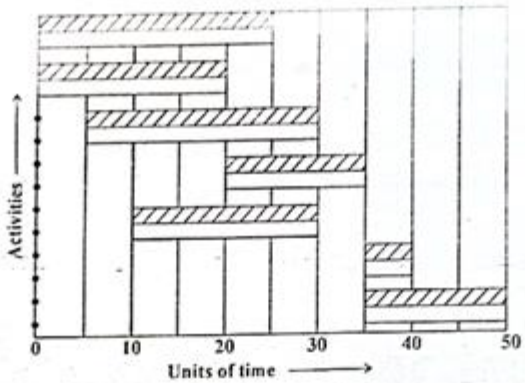
### TECHNIQUES USED FOR PROJECT MANAGEMENT

1. Bar chart
   - Firstly introduced by Henry Gantt around 1900 AD

*Features of bar chart are :*

It is a pictorial chart. It has two co-ordinate system, the horizontal co-ordinate represents the elapsed time and vertical represents the job or activity performed. The beginning and end of each bar represents starting and finishing time of particular activity respectively. The length of bar shows the time of completion.

- Jobs can be concurrent or can be started one after other. So some bars can run parallel or overlap each other or may run serially.



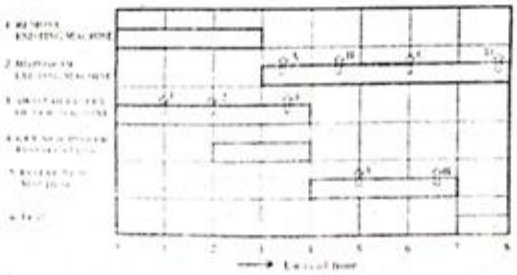

**Limitations of bar chart :**

1. *Lack of degree of details* : Only major activities are shown in bar chart and subactivities can not be separated out. Hence effective control over the activities in big projects can not be achieved.
2. A bar chart does not show progress of work hence it can not be used as a control device.
3. A bar chart is unable to depict interdependencies of activities clearly.
4. Bar charts are not useful in the projects where there are uncertainties in determination or estimation of time required for completion of various activities.
5. Bar chart can not distinguish between critical and noncritical activities hence resource smoothening and resource levelling can not be done.

Bar chart diagrams are useful for only small size conventional projects, specially construction and manufacturing projects, in which time estimates can be made with fair degree of certainty.

**2. Mile - Stone chart :**

It is a modification over original Gantt chart. Milestones are key events of main activities represented by bar. Therefore they give idea about completion of sub activities.



- Controlling can be better achieved with the help of milestone charts, but still activity interrelationship ,and accountability of time uncertainty can not be depicted which can be overcome in network technique.

**2. Network methods :**

- It is an outcome of the improvements in the milestone charts.
- They are called by various names such as PERT, CPM, UNIVICS, LESS, TOPS and SCANS.
- However all these have emerged from the two major network systems.
  1. PERT
  2. CPM

■■■

## UNIT - 2

## NETWORK TECHNIQUE

**Advantages of network method over bar chart and milestone chart :**

1. Interrelation ship between activities and events of a project is clearly shown.
2. The project can be treated as an integrated whole with all its subactivites clearly related with each other. It helps in controlling the project.
3. Network method is usefull for very complicated projects having large number of activities.
4. It indicates the time required in between two activities is rescheduling of a project is possible.
5. Time uncertainty is accounted so it is also useful for research and development projects

### ELEMENTS OF NETWORK

Following are elements of a network.

**1. Event :**

- An event is either start or completion of an activity.
- Events are significant points in a project which act as a control point of the project.
- An event is an instant of time and if does not require time or resources.

*Following are examples of an event :*

(i) All parts assembled

(ii) A budget prepared

(iii) Construction completed

*Following can not be events :*

(i) Prepare budget

(ii) Assemble parts

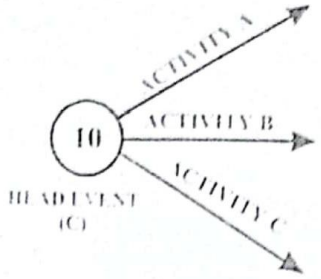
(iii) Excavate trench

- Events are represented by nodes in a network. It may have any of the following shapes

(i) Circular (ii) Square (iii) Rectangular (iv) Oval

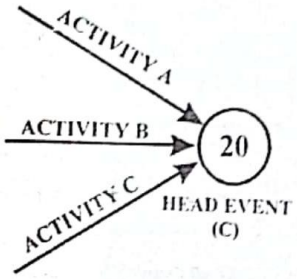
Most commonly adopted is circular shape of events

- *A tail event or a start event of a project :* it has only outgoing arrows.



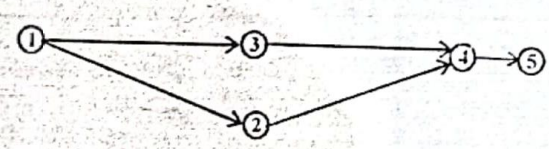

Event 10 is a tail event. Arrows represent job or activity of a project.

- *Head event or final event* : It is finish of a project having only incoming arrows.



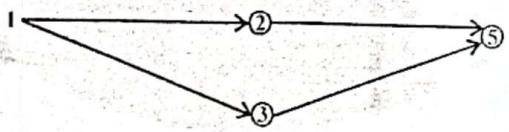

Event 20 is a head event.

- ***Dual role events*** : All events except 1st and last event of a project are duel role events. They have both incoming and outgoing arrows.




Events 2, 3, 4, are duel role events.

- ***Successor events :*** The event o: events that follow another event are called successor events to that event.




Event 2, 3 are successor events of 1.

- *Predecessor events :* The event or events that occur before another event are called predecessor event to that event.

In above fig. events 2, 3 are predecessor to events 5.

*Note :* It should be noted there can be only one tail event and one head event in a project.

2. **Activity :**

Activity is actual performance of a job.

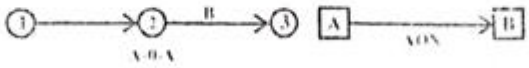
It requires time and resources for its completion

*Following are examples of an activity*

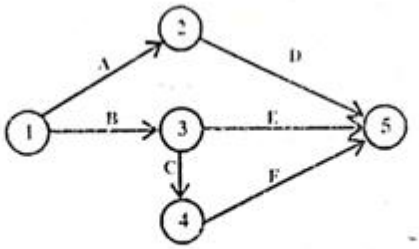
1. Excavate trench

2. Mix concrete
3. Prepare budget

*Note :* In A-O-A system (Activity on Arrow net work system) activity is represented by arrows between events while in A-O-N (Activity On Node system) activities are represented by nodes. In A-O-N system events have no places.




Here A & B activities are represented in two different system.

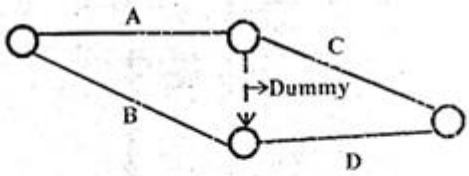



- The activities which can be perform simultaneously are called **parallel activities**. In above Fig. activities A, B & C are parallel activities.
- Activity or activities that can be performed after performance of other activity are known as **successor activities** to that activity. Activity F is successor activity to activity C in above Figure.

## Dummy

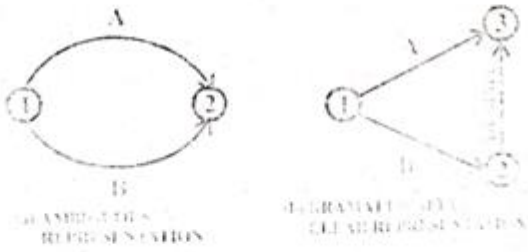
- A dummy is a type of operation which neither requires time nor resources, but it denotes dependency among the activities.
- It is represented by dashed arrow.

In the following figure a dummy is shown.



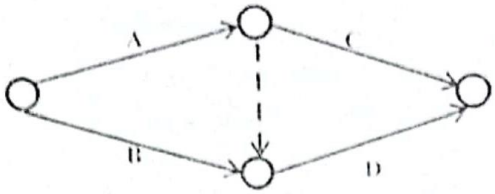

*Dummy is used to serve **following purposes***

(i) *Grammetrical purpose* - To prevent two arrows having common beginning and common end.




(ii) *Logical purpose* : To show relation with other activities

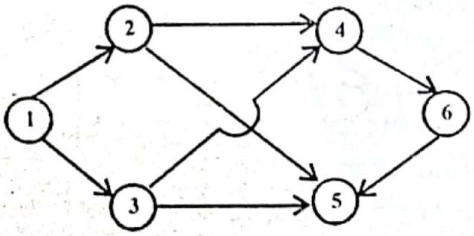
Here dummy is required to show D can start after completion of A & B both.




**Unnecessary dummies should be removed.**

## RULES OF A NETWORK

1. There can be only initial and one final event.
2. An event can not occur unless all preceding activities are completed.
3. An event can not occur twice.
4. Number of arrows should be equal to number of activities
5. Time should always flow from left to right
6. Length of arrow does not show any magnitude. Straight arrows should be taken as far as possible
7. Arrows should normally not cross each other. If it is necessary to cross, one should be bridged over the other.

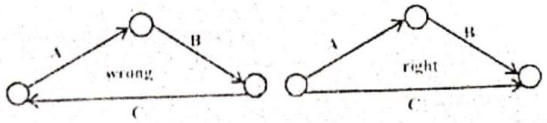



### Fulkersons's rule for numbering the events

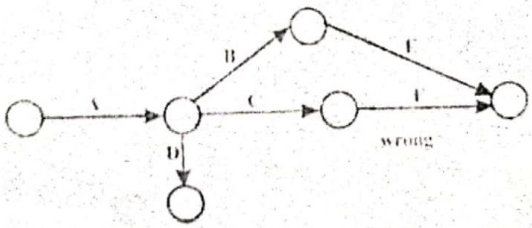
1. The single initial event is numbered as (0, 1, 10 etc.)
2. All arrows emerging out of the initial one are neglected. Doing so the created one or more new initial events are numbered as 2,3,4 or 20, 30, 40 etc.
3. Step - 2 is repeated unless all events are numbered.

### Errors in network

1. *Looping error* : loops should not be formed.



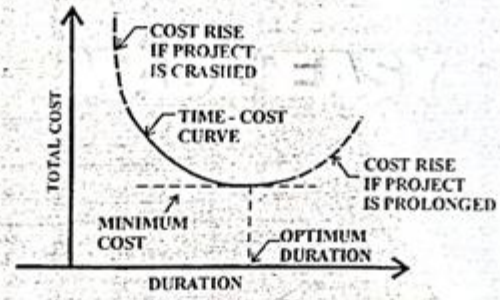

2. *Dangling error* : A project network must have only are dead end



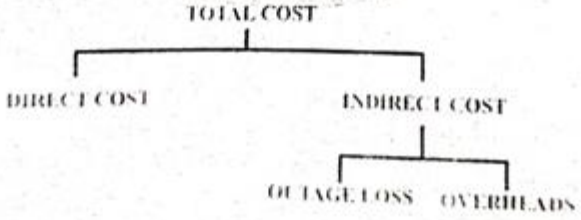
# CRASHING OF A NETWORK
# (Cost Model Analysis)

- In CPM, time is related to cost and the object is to develop an optimum time-cost relationship.
- The overall project duration can be reduced by reducing the duration of only the critical activities in the project network. The durations of such activities may be reduced in two ways.
  (a) by deploying more resources for the early completion of such activities.
  (b) by relaxing the technical specifications for such activities.
- In whole of CPM Cost Model, we will be assuming that project duration is reduced by deploying more resources on critical activities.
- In CPM, there are two time and cost estimates for each activity: 'normal estimate' and crash estimate'. In the normal estimate, the emphasis is on cost with time being associated with minimum cost. The 'crash' estimate involves the absolute minimum time required for the job and the cost necessary to achieve it. Here the emphasis is on 'time'.

## PROJECT COST




Total Project cost is the sum of two separate cost :
(a) the direct cost for accomplishing the work, and (b) the indirect cost related to the control or direction of that work, financial overhead, lost production, and the like.
The components of the total cost are depicted in Fig.



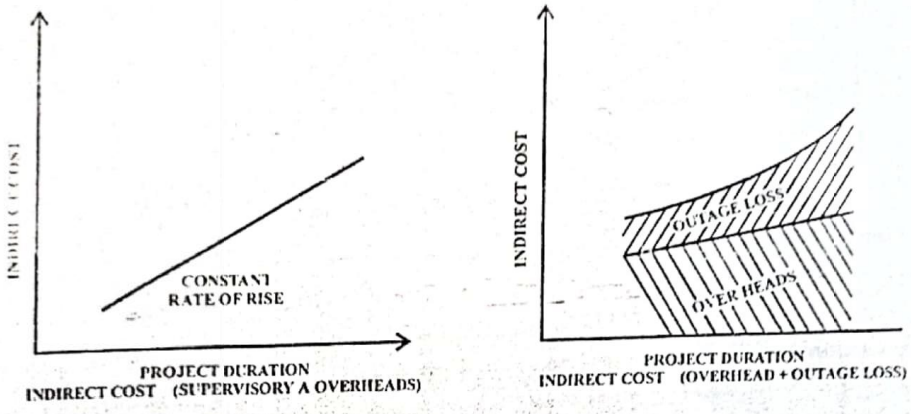

Components of project cost

### Indirect Project Cost

- Indirect costs on a project are those expenditures which cannot be apportioned or clearly allocated to the individual activities of a project, but are assessed as a whole. The indirect cost includes the

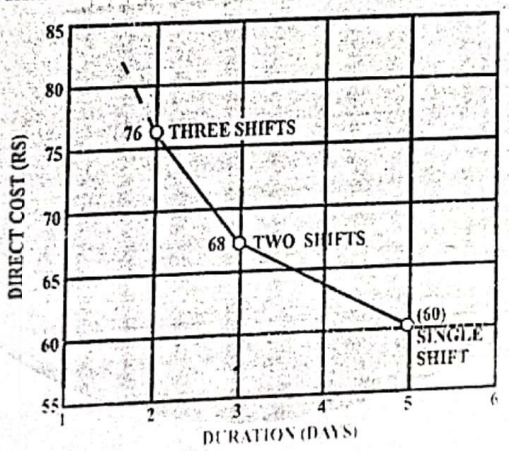
expenditure related to administrative and establishment charges, overhead, supervision, expenditure on a central store organisation, loss of revenue, lost profit, penalty etc.

- Indirect cost rises with increased duration. Considering only overhead and supervision. It would be represented by a straight line, with a slope equal to daily overhead.
- But when there is a loss in profits, due to inability to meet demand or due to some penalty due to delay, a corresponding cost increase must be added to the cost of overheads, producing the curve. Such a loss is called the outage loss.
- The total indirect cost curve will thus be curved.




## Direct Project Cost

These include labour cost, material cost, equipment cost etc.



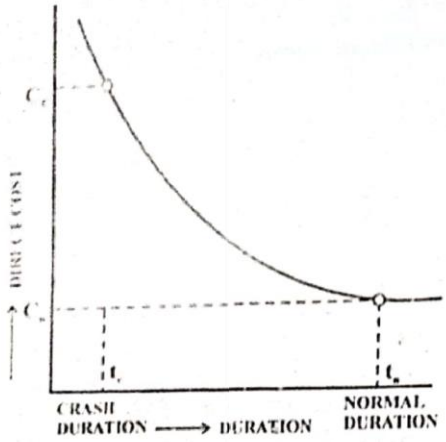

The direct cost curve, having many segments, thus falls with increase in duration. However, the total indirect cost curve rises with increase in duration.

The project has the highest cost corresponding to the crash duration, and has normal cost corresponding to the normal duration.

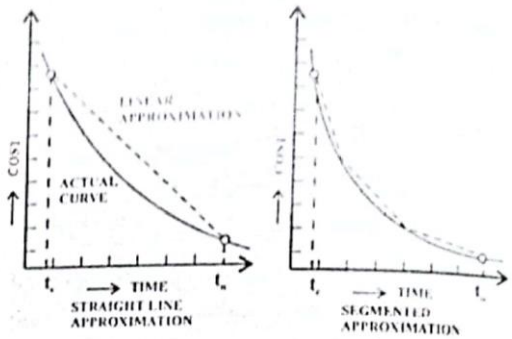
**Normal time ($t_n$) :** Normal time is the standard time that an estimater would usually allow for an activity.

**Crash time ($t_c$) :** Crash time is the minimum possible time in which an activity can be completed, by employing extra resources. Crash time is that time, beyond which the activity cannot be shortened by any amount of increase in resources.

- **Normal cost ($C_n$)** : This is direct cost required to complete the activity in normal time duration.
- **Crash cost ($C_c$)** : This is the direct cost corresponding to the completion of the activity within crash time.




**Generalised direct cost-time curve.**




**Direct cost curve approximation**

- The straight line or segmented approximation of the direct cost curve is helpful in carrying out the project cost analysis. In such analysis, the cost slope is used.

**Cost Slope**

- The cost slope is the slope of the direct cost curve, approximated as straight line. It is defined as follows:

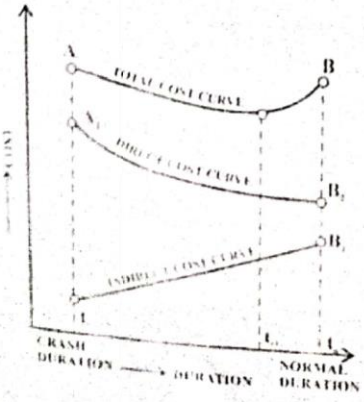
$$\text{Cost slope} = \frac{\text{crash cost - normalcost}}{\text{normal time - crash time}}$$

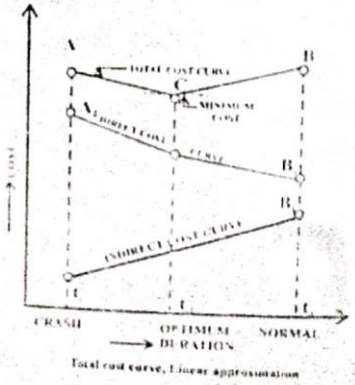
$$\text{or} \qquad CS = \frac{C_c - C_n}{t_n - t_c} = \frac{\Delta c}{\Delta t}$$

- The segmented approximation of cost curve, having multiple cost slopes, is more accurate but calculations are more involved. Generally, single cost slope is assumed.

**Total Project Cost and Optimum Duration**

- The total project cost is the sum of the direct cost and indirect costs.
- We find that the minimum total cost is obtained at some duration known as the optimum duration. The corresponding cost is known as the minimum cost. If the project duration is increased, total cost will increase, while if project duration is decreased to the crash value, project cost will be the highest.




Total cost curve, Linear approximation

**Steps in crashing :**

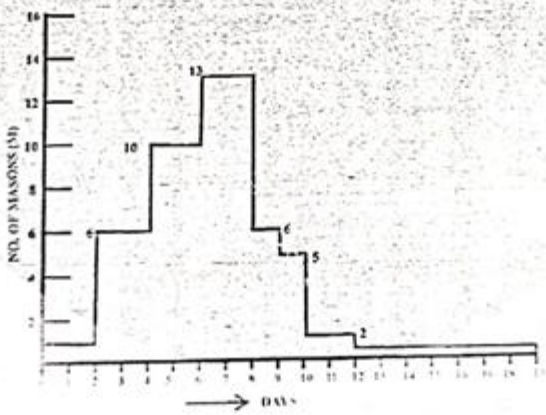
1. Estimate project duration and find the critical path.
2. Find cost slope of all activities.
3. The critical activity having *minimum cost slope* is crashed in 1st stage. The next stage crashing will involved activity having second lower cost slope in critical path.
4. Total cost of project at this stage is calculated.
5. Step 3 & 4 are repeated till all activities of project are crashed along critical paths, corresponding time is crash time of project.
6. It is to be noted that only critical activities should be crashed.

■■■

## UNIT - 6

## RESOURCE ALLOCATION

- 'Resource' is a physical variable required or completion of activities. It can be material, manpower, machinary, space, money or time resources.
- Due to limited resources or limited project duration it is required to allocate resources in the way so that more or less uniform demand through out can be achieved.
- "Resource allocation" is deciding the resources to each activity.
- The diagram which shows variation in the requirement of resources with time is called *"Resource usage profile" or "Histogram"*.




- These are helpful to know requirement of resources at different time in different activities.
- *Resource allocation can be achieved by following two processes*

1. Resource smoothening

   Resources are considered unlimited. Project duration is maintained and critical activities remain unchanged. Start time of some of the critical activities are shifted within their available floats to create uniform demand throughout.

2. Resource Leveling

   Resources are considered unlimited. Project duration may be changed. Activities are rescheduled

# Quiz

1. Which of the following is not a phase of project management?
a) Project planning
b) Project scheduling
c) Project controlling
d) Project being

2. Who introduced the bar charts?
a) Williams henry
b) Henry Gantt
c) Jane Gantt
d) Joseph henry

3. Bar charts were modified later to obtain the milestone charts.
a) True
b) False

4. The full form of PERT is _____
a) Program Evaluation and Rate Technology
b) Program Evaluation and Robot Technique
c) Program Evaluation and Robot Technology
d) Program Evaluation and Review Technique

5. The full form of CPM is _____
a) Critical Path Method
b) Control Path Method
c) Critical Plan Management
d) Control Path Management

6. In bar charts, which colour is used to show the actual progress?
a) Red
b) Black
c) Blue
d) Green

7. A PERT network is activity-oriented while a CPM network is event-oriented.
a) True
b) False

8. _____ are used to represent activity in a network diagram.
a) Circles
b) Squares
c) Rectangles
d) Arrows

9. The shortest possible time in which an activity can be achieved under ideal circumstances is known as _____
a) Pessimistic time estimate
b) Optimistic time estimate
c) Expected time estimate
d) The most likely time estimate

10. According to the time estimates made by the PERT planners, the maximum time that would be needed to complete an activity is called as _____
a) The most likely time estimate
b) Optimistic time estimate
c) Pessimistic time estimate
d) Expected time estimate

11. In a network, a critical path is the time-wise shortest path.
a) True
b) False

12. The difference between the maximum time available and the actual time needed to perform an activity is known as _____
a) Free float
b) Independent float
c) Total float
d) Half float

13. In time-cost optimization of a project, crashing is done.
(A) On all the activities
(B) On all the activities lying on the critical path
(C) Only on activities lying on the original critical path and having flatter cost slopes
(D) On original critical activities and those that become critical at any stage of crashing in the order of ascending cost slope

14. Which of the following does not represent an activity?
(A) Site located
(B) Foundation is being dug
(C) The office area is being cleaned
(D) The invitations are being sent

15. In resources levelling
(A) Total duration of project is reduced
(B) Total duration of project is increased
(C) Uniform demand of resources is achieved
(D) Cost of project is controlled

16. 4. Sensitivity analysis is a study of

(A) Comparison of profit and loss
(B) Comparison of assets and liabilities
(C) Change in output due to change in input
(D) Economics of cost and benefits of the project

17. . Preliminary project report for a road project must contain
(A) The detailed estimated cost based on detailed design
(B) The several alternatives of the project that have been considered
(C) The soil survey, traffic survey, concept design and approximate cost
(D) The contract documents for inviting tenders

18. For which of the following materials, the output of power shovels for a fixed shovel size will be maximum
(A) Moist loam
(B) Good common earth
(C) Well blasted rock
(D) Wet sticky clay

19. If the output of a drag-line for 90° angle of swing at optimum depth of cut is X, then the output for 120° angle of swing at 120 % of optimum depth of cut will be
(A) Equal to X
(B) More than X
(C) Less than X
(D) Any of the above

20. n PERT analysis, the time estimates of activities and probability of their occurrence follow
(A) Normal distribution curve
(B) Poisson's distribution curve
(C) Beta distribution curve
(D) None of the above

21. Free float is mainly used to
(A) Identify the activities which can be delayed without affecting the total float of preceding activity
(B) Identify the activities, which can be delayed without affecting the total float of succeeding activity
(C) Establish priorities
(D) Identify the activities which can be delayed without affecting the total float of either the preceding or succeeding activities

22. Grader is used mainly for
(A) Trimming and finishing
(B) Shaping and trimming
(C) Finishing and shaping
(D) Finishing, shaping and trimming

23. Which of the following surfaces will give highest rolling resistance for a rubber tyred vehicle?
(A) Concrete
(B) Loose sand
(C) Asphalt
(D) Firm earth

24. Which of the following earth moving machines has the shortest cycle time?
(A) Drag line
(B) Hoe
(C) Clam shell
(D) Dipper shovel

25. Updating may result in
(A) Change of critical path
(B) Decrease of project completion time
(C) Increase of project completion time
(D) All of the above

26. The time by which a particular activity can be delayed without affecting the preceding and succeeding activities is known as
(A) Total float
(B) Free float
(C) Interfering float
(D) Independent float

27. During the construction period, price variation clause in contracts caters to
(A) Increase in rates of only important materials
(B) Variation in cost in materials element, labour element and petrol-oil-lubricant element
(C) Variation in total cost of the project on an ad hoc basis
(D) Rate of inflation

**SOLUTION**: 1.d, 2.b, 3.a, 4.d, 5.a, 6.d, 7.b, 8.d, 9.b, 10.c, 11.b, 12.c, 13.d, 14.a, 15.c, 16.c, 17.c, 18.a, 19.c, 20.c, 21.b, 22.d, 23.b, 24.d, 25.d, 26.d, 27.b

## Sample Viva Questions

1. What is Critical path method?
2. At a work site, statistical quality control of concrete means?
3. What is a critical ratio scheduling?
4. For a given activity, the optimistic time, pessimistic time and the most probable estimates are 5, 17 and 8 days respectively, The expected time is?
5. In the time-cost optimisation, using CPM method for network analysis, the crashing of the activities along the critical path is done starting with the activity having?
6. The time with which direct cost does not reduce with the increase in time is known as?
7. Interfering float is the difference between?
8. While filling the tender for any work, what all should the contractor must considers?
9. Power stations are generally treated as?
10. Bar charts are suitable for?
11. The time corresponding to minimum total project cost is?
12. Who all are the part of "Construction team"?
13. PERT technique of network analysis is mainly useful for?
14. The independent float affects only _____ Activity?
15. The time by which activity completion time can be delayed without affecting the start of succeeding activities, is known as?
16. Site order book is used for recording?
17. The direct cost of a project with respect to normal time is?
18. What is the objective of technical planning?
19. Various activities of a project, are shown on bar charts by?
20. Total float for any activity is defined as the difference between?