KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University)
(Established Under Section 3 of UGC Act, 1956)
Eachanari Post, Coimbatore-641021.Tamilnadu, India.

FACULTY OF ENGINEERING
DEPARTMENT OF CIVIL ENGINEERING

15BECE7E08 CONSTRUCTION RESOURCE PLANNING AND MANAGEMENT 3 0 0 3 100

OBJECTIVE:

At the end of this course the students should have learnt construction planning, Scheduling procedures and techniques, cost control monitoring and accounting, Quality control and safety during construction, Organization and use of project information

UNIT I 9

Construction Planning: Basic concepts in the development of construction plans-choice of Technology and Construction method-Defining Work Tasks- Definition- Precedence relationships among activities-Estimating Activity Durations-Estimating Resource Requirements for work activities-coding systems

UNIT II 9

Scheduling Procedures And Techniques: Relevance of construction schedules-Bar charts - The critical path method-Calculations for critical path scheduling-Activity float and schedules-Presenting project schedules-Critical path scheduling for Activity-on-node and with leads, Lags and Windows-Calculations for scheduling with leads, lags and windows-Resource oriented scheduling-Scheduling with resource constraints and precedences -Use of Advanced Scheduling Techniques-Scheduling with uncertain durations-Crashing and time/cost trade offs -Improving the Scheduling process – Introduction to application software

UNIT III 9

Cost Control Monitoring And Accounting: The cost control problem-The project Budget-Forecasting for Activity cost control - financial accounting systems and cost accounts-Control of project cash flows-Schedule control-Schedule and Budget updates-Relating cost and schedule information

UNIT IV 9

Quality Control And Safety During Construction: Quality and safety Concerns in Construction-Organizing for Quality and Safety-Work and Material Specifications-Total Quality control-Quality control by statistical methods -Statistical Quality control with Sampling by Attributes-Statistical Quality control by Sampling and Variables-Safety.

UNIT V 9

Organization And Use Of Project Information: Types of project information-Accuracy and Use of Information-Computerized organization and use of Information -Organizing information in databases-relational model of Data bases-Other conceptual Models of Databases-Centralized database Management systems-Databases and application programs-Information transfer and Flow.

TOTAL HRS: 45

TEXT BOOK:

S.No	Title of Book	Author of Book	Publisher	Year of Publishing
1	Construction Project Management Planning, Scheduling and Control	Chitkara, K.K	Tata McGraw-Hill Publishing Co., New Delhi.	2008

REFERENCES:

S.No	Title of Book	Author of Book	Publisher	Year of Publishing
1	Project Management with CPM, PERT and Precedence Diagramming,	Moder.J. C.Phillips and Davis	Third Edition Van No strand Reinhold Co	2005
2	Scheduling Construction projects	Willis. E.M.	John Wiley and Sons	2008

WEBSITES:

- http://www.icivilengineer.com
- http://www.engineeringcivil.com/
- http://www.aboutcivil.com/
- http://www.engineersdaily.com
- http://www.asce.org/
- http://www.cif.org/
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LECTURE PLAN

CONSTRUCTION RESOURCE PLANNING AND MANAGEMENT
15BECE7E08

LECTURER : **Mrs.M.Vidhya**
SEMESTER : **VII (2018-2019)**
NUMBER OF CREDITS : **3**
COURSE TYPE : **Core**

S.No	Hours	Portions	Text book	Page no
		UNIT I - CONSTRUCTION PLANNING		
1	2	Basic concepts in the development of construction plans	T_1	8
2	1	Choice of Technology and Construction method-Defining Work Tasks	T_1	10
3	1	Definition- Precedence relationships among activities	T_1	147
4	1	Estimating Activity Durations	T_1	86
5	2	Estimating Resource Requirements for work activities	T_1	92
6	2	Coding systems	R_1	115
		Total Hours: 09		
		UNIT II - SCHEDULING PROCEDURES AND TECHNIQUES		
7	1	Relevance of construction schedules, Bar charts	T_1	181
8	1	The critical path method-Calculations for critical path scheduling	T_1	118
9	1	Activity float and schedules	T_1	185
10	1	Presenting project schedules-Critical path scheduling for Activity-on-node and with leads, Lags and Windows	T_1	195
11	1	Calculations for scheduling with leads, lags and windows	T_1	191
12	1	Resource oriented scheduling-Scheduling with resource constraints and precedence	T_1	190
13	1	Use of Advanced Scheduling Techniques	T_1	232
14	1	Scheduling with uncertain durations Crashing and time/cost trade offs	T_1	240
15	1	Improving the Scheduling process – Introduction to application software		
		Total Hours: 09		
		UNIT III - COST CONTROL MONITORING AND ACCOUNTING		
16	2	The cost control problem	T_1	440
17	1	The project Budget	T_1	442
18	1	Forecasting for Activity cost control	T_1	446
19	1	financial accounting systems and cost accounts	T_1	449
20	1	Control of project cash flows	T1	452
21	1	Schedule control	T_1	455
22	1	Schedule and Budget updates	T_1	457
23	1	Relating cost and schedule information	T_1	464
		Total Hours: 09		
		UNIT IV – QUALITY CONTROL AND SAFETY DURING CONSTRUCTION		
24	2	Quality and safety Concerns in Construction	T_1	222
25	1	Organizing for Quality and Safety	T_1	246
26	1	Work and Material Specifications	T_1	276
27	1	Total Quality control	T1	292
28	1	Basic elements of quality	T1	305
29	1	management quality control, factors affecting quality of construction	T_1	316
30	1	safety management	R_1	285
31	1	Common causes of accidents, safety precautions at construction sites.	T_1	337
		Total Hours: 09		
		UNIT V- ORGANIZATION AND USE OF PROJECT INFORMATION		
32	2	Types of project information, Accuracy and Use of Information	T_1	530

33	1	Computerized organization and use of Information	T_1	537
34	1	Organizing information in databases	R_1	295
35	1	relational model of Data bases	T_1	534
36	1	Other conceptual Models of Databases	T_1	537
37	1	Centralized database Management systems	R_1	541
38	1	Databases and application programs	T_1	542
39	1	Information transfer and Flow.	R_1	548
		Total Hours: 09		
		Total Hours: 45		

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- http://www.icivilengineer.com
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- http://www.engineersdaily.com
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- http://www.cif.org/
- http://icevirtuallibrary.com/
- http://www.ice.org.uk/

JOURNALS:

- Journal of Construction Engineering and Management
- Journal of structural engineering
- Construction Business Review
- Journal of civil engineering
- Construction Management and Economics

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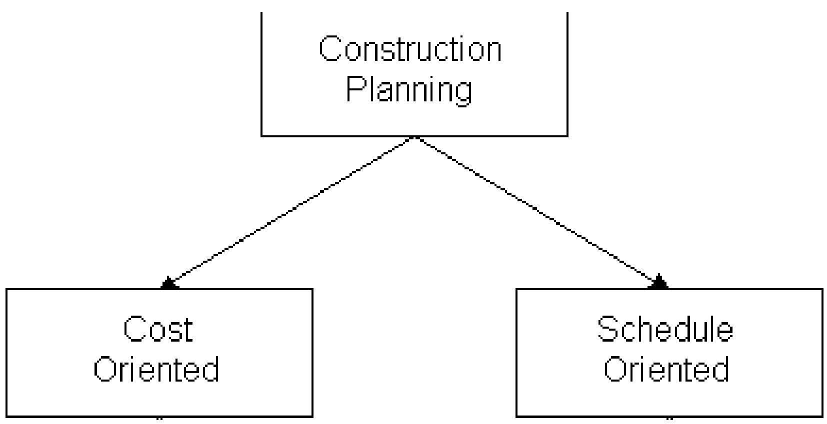
Unit-I Construction Planning

Construction Planning

Generally planning is the process of making the idea to output. Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work

Steps involved in Construction Planning/ Basic concept of developing a construction plan

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded. In addition to these technical aspects of construction planning, it may also be necessary to make organizational decisions about the relationships between project participants and even which organizations to include in a project.



A good construction plan should satisfy economy in cost and time saving and serviceability

Steps involved in Construction Planning

1. Doccument study (Technical and commercial aspect)
2. Investigation of site (Soil type, Climatic condition, Availability of nearby resources, Transport facilities, investigation nearby structures)
3. Developing idea of the project (Preparing key plan)
4. Planning drawings and designs

5. Estimation of resources (Materials, Equipments and Machineries)
6. Planning of construction technology and methods
7. Planning of Activities
8. Planning of project time
9. Planning of contract/Sub contract
10. Estimation total cost of the project

Advantages and Limitations of Planning

Planning is one of the most important functions of management. It is basic to all other functions of management. Planning defines the goals of the organization. There will not be proper organization and direction without proper planning.

1. Attention on objectives: with the help of planning, the management can clearly define the organizational goals. Therefore the management can only concentrate on the achievement of these goals. In the same way, planning also helps the managers in prioritizing the organizational goals. Therefore, the objectives of the organization that are more important and need to be achieved first of all can receive the attention of the managers while the other objectives can be achieved later on.

2. Better utilization of resources: a significant advantage provided by planning is that it helps the managers in utilizing the resources available with the organization in a better way. Therefore, in this process the resources that are available with the organization are identified first of all and then the operations of the organization are planned on the basis of these resources. In this way, with the help of planning, the managers are able to use all the resources of the organization in the best possible way.

3. Minimizing uncertainties: planning is always related to the future. However it is also true that the future cannot be predicted with certainty and a lot of changes keep on taking place in the business environment. Therefore, with the help of planning, the managers try to predict what is going to happen in future and then make plans to achieve the organizational goals. In this way, planning helps in reducing the uncertainties of the future as the decisions are based on the past experiences and also the situation that is being faced by the organization at present.

4. Economy in operations: in case of planning, first of all the objectives of the organization are decided and then the best course of action that can be adopted for achieving these goals is decided. In this way the operations that are selected for this purpose are the better alternative out of all the alternatives that are available and this result in an economy in operations. It also allows avoiding the method of trial and error and at the same time, the resources of the organization are not wasted while making choices. Such economy can be achieved by all the departments of the organization like production, sales and finance etc.

5. Encourages innovation and creativity: A better system of planning is the system that is capable of encouraging the managers to come up with new ways of doing things. In this way, it should encourage creative thinking and innovation among the managers because in this case they think regarding new ways while involved in the process of planning. This process should provide awareness regarding the individual participation and at the same time it should encourage an atmosphere of openness which in turn helps in achieving the goals of the organization.

6. Better coordination: as the organizational goals are common, all the persons make concerted efforts to achieve these objectives. At the same time, planning also helps in avoiding the duplication of efforts. In this way planning results in better coordination and ultimately results in the achievement of better results.

7. Facilitates control: the process of planning and control cannot be separated from each other. The process of planning helps in deciding the objectives of the organization, and also lays down the standards of performance. This helps the management in evaluating the performance of different persons in the organization. At the same time, if there is any deviation in performance, early steps can be taken by the management to rectify this position.

8. Allows management by exception: the meaning of management by exception is that the management of the organization is not required to be involved in all the activities. Therefore if certain things are going well, there is no need that the management should focus on these things. Therefore, the management is required to intervene only if things are not going according to plan. While the organizational objectives are determined by the process of planning, all efforts can be made to achieve these objectives. The management is required to interfere only when it appears that the things are not going well and these objectives may not be achieved. In this way, when management by exception is introduced, the managers have more time to indulge in the process of planning instead of spending time in directing the routine activities of the organization.

9. Facilitates delegation: with the help of the process of planning, the management can dedicate the powers. In this case, the goals are assigned to different persons. However, these persons may need the authority to achieve these goals. In this way, the process of planning also facilitates the delegation of authority within the organization.

Limitations of planning

There are a large number of advantages associated with planning however there can be certain obstacles and limitations faced by the process of planning. In the same way, it also needs to be noted that planning cannot be considered as a remedy for all the problems faced by the organization. Planning can only help in reducing the uncertainties of the future and that too, only up to a certain extent. In this way, the limitations of planning can be described as follows:-

Lack of reliable data: The process of planning is based on different facts and figures that have been provided to the managers while they are involved in the process of planning. However, in case the data that has been provided to the managers is not reliable, it is possible that the decisions that are based on this data can also be unreliable. In this way, the purpose of planning can be defeated if the managers are not provided with relevant data at the time of planning.

Expensive: it also needs to be noted that the process of planning can be very expensive. For example, collecting information and testing different course of action require much investment by the company. In the same way, sometimes these expenses can be so high that it is very difficult for small enterprises to become involved in planning. Therefore, particularly the long-term planning is out of reach for a large number of organizations due to the heavy expenses that are involved in it. It is very important that the utility that has been derived from planning should not be less than the expenses that have been incurred on planning.

Time-consuming: the process of planning can be very time consuming and this in turn reduces the practical utility of planning. It is a time-consuming process and the actions that need to be taken regarding various operations can be delayed if proper plans have not been formulated on time. Such a delay may also cause a loss of opportunities for the organization. Particularly when time is of essence, the advanced planning is not of much help. In some cases, there can be circumstances where immediate action is required and therefore it is not possible to wait that first of all the process of planning should be completed.

Sudden emergencies: there can be certain cases where an emergency may arise. In such a case, quick action is required by the organization and therefore advance planning is not possible. At the same time, many times it is not possible to anticipate these situations. On the other end if these emergencies can be anticipated or if they occur regularly, it may be possible to undertake planning in order to deal with these emergencies also.

External factors may decrease the utility: apart from the internal factors, there can be certain external factors that may have an adverse impact on planning. Among these factors, there are social, political, economic and technological factors. In the same way, the general environment at the national as well as international level also acts as a limitation when it comes to the effectiveness of the process of planning.

Resistance to change: generally, it has been seen that most of the people do not want to change. The passive outlook of these persons towards the new ideas can also be considered as a limitation when it comes to planning. Therefore there is a psychological barrier according to which the executives are also more concerned with the present as compared to the future. The reason is that while the present is more certain as compared to the future, the present is also more desirable. In this way the business organizations generally see the resistance to change.

Choice of Technology and Construction Method

The selection of construction methods is a complex decision process which consider multiple factors such as cost, time, quality, physical characteristics of the element to build, characteristics of the construction method, the environment, the risk of each alternative, and available resources

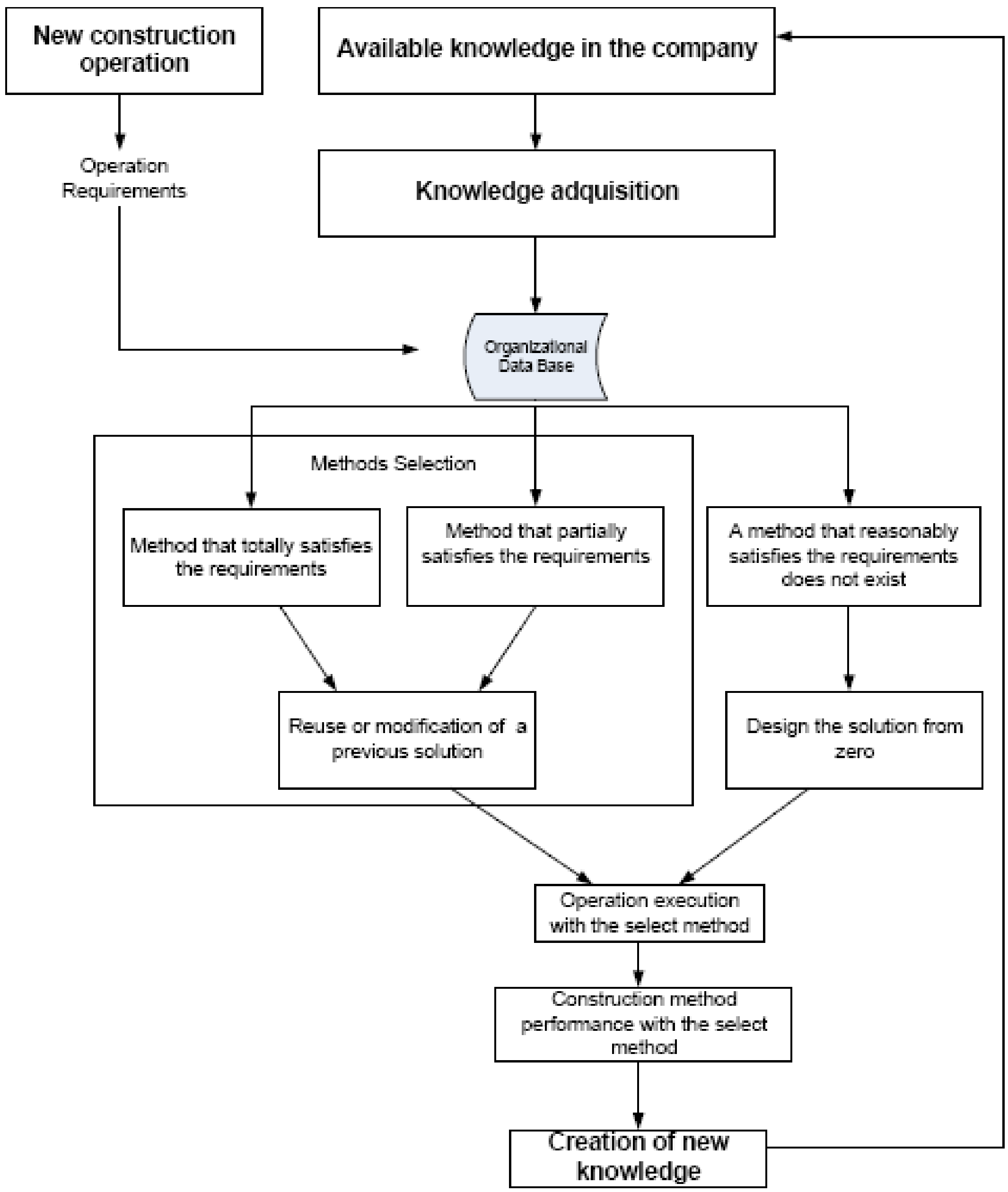
The appropriate selection of construction methods to be used during the execution of a construction project is a major determinant of high productivity, but sometimes this selection process is performed without the care and the systematic approach that it deserves, bringing negative consequences. This paper proposes a knowledge management approach that will enable the intelligent use of corporate experience and information and help to improve the selection of construction methods for a project. Then a knowledge-based system to support this decision-making process is proposed and described. To define and design the system, semi structured interviews were conducted within three construction companies with the purpose of studying the way that the method' selection process is carried out in practice and the knowledge associated with it. A prototype of a Construction Methods Knowledge System (CMKS) was developed and then validated with construction industry professionals.

Procedure for Choosing Choice of Technology And Construction Method

As in the development of appropriate alternatives for facility design, choices of appropriate technology and methods for construction are often ill-structured yet critical ingredients in the success of the project. For example, a decision whether to pump or to transport concrete in buckets will directly affect the cost and duration of tasks involved in building construction. A decision between these two alternatives should consider the relative costs, reliabilities, and availability of equipment for the two transport methods. Unfortunately, the exact implications of different methods depend upon numerous considerations for which information may be sketchy during the planning phase, such as the experience and expertise of workers or the particular underground condition at a site.

In selecting among alternative methods and technologies, it may be necessary to formulate a number of construction plans based on alternative methods or assumptions. Once the full plan is available, then the cost, time and reliability impacts of the alternative approaches can be reviewed. This examination of several alternatives is often made explicit in bidding competitions in which several alternative designs may be proposed or *value engineering* for alternative construction methods may be permitted. In this case, potential constructors may wish to prepare plans for each alternative design using the suggested construction method as well as to prepare plans for alternative construction methods which would be proposed as part of the value engineering process.

In forming a construction plan, a useful approach is to simulate the construction process either in the imagination of the planner or with a formal computer based simulation technique. By observing the result, comparisons among different plans or problems with the existing plan can be identified. For example, a decision to use a particular piece of equipment for an operation immediately leads to the question of whether or not there is sufficient access space for the equipment. Three dimensional geometric models in a computer aided design (CAD) system may be helpful in simulating space requirements for operations and for identifying any interference. Similarly, problems in resource availability identified during the simulation of the construction process might be effectively forestalled by providing additional resources as part of the construction plan.



Note: You may write any innovative techniques as example

Example 1: roadway rehabilitation

An example from a roadway rehabilitation project in Pittsburgh, PA can serve to illustrate the importance of good construction planning and the effect of technology choice. In this project, the decks on overpass bridges as well as the pavement on the highway itself were to be replaced. The initial construction plan was to work outward from each end of the overpass bridges while the highway surface was replaced below the bridges. As a result, access of equipment and concrete trucks to the overpass bridges was a considerable problem. However, the highway work could be staged so that each Overpass Bridge was accessible from below at prescribed times. By pumping concrete up to the overpass bridge deck from the highway below, costs were reduced and the work was accomplished much more quickly.

Example 2: Laser Leveling

An example of technology choice is the use of laser leveling equipment to improve the productivity of excavation and grading. In these systems, laser surveying equipment is erected on a site so that the relative height of mobile equipment is known exactly. This height measurement is accomplished by flashing a rotating laser light on a level plane across the construction site and observing exactly where the light shines on receptors on mobile equipment such as graders. Since laser light does not disperse appreciably, the height at which the laser shines anywhere on the construction site gives an accurate indication of the height of a receptor on a piece of mobile equipment. In turn, the receptor height can be used to measure the height of a blade, excavator bucket or other piece of equipment

Example 3: 3D Volumetric Construction

3D Volumetric construction (also known as modular construction) involves the production of three-dimensional units in controlled factory conditions prior to transportation to site. Modules can be brought to site in a variety of forms, ranging from a basic structure to one with all internal and external finishes and services installed, all ready for assembly. The casting of modules uses the benefits of factory conditions to create service-intensive units where a high degree of repetition and a need for rapid assembly on-site make its use highly desirable.

This modern method of construction offers the inherent benefits of concrete, such as thermal mass, sound and fire resistance, as well as offering factory quality and accuracy, together with speed of erection on-site.

Example 4: Tunnel Form

Tunnel form is a formwork system that allows the contractor to build monolithic walls and slabs in one operation on a daily cycle. It combines the speed, quality and accuracy of factory/offsite produced ready-mixed concrete and formwork with the flexibility and economy of cast in-situ construction.

Example 5: Insulating Concrete Formwork

Insulating Concrete Formwork (ICF) systems consist of twin-walled, expanded polystyrene panels or blocks that are quickly built up to create formwork for the walls of a building. This formwork is then filled with factory produced, quality assured, and ready-mixed concrete to create a robust structure. The expanded polystyrene blocks remain to provide high levels of thermal insulation and the concrete core provides robustness and good levels of sound insulation.

Example 6: Precast Foundations

Precast concrete systems can be used to rapidly construct foundations. The elements are usually to a bespoke design and cast in a factory environment, giving assured quality for the finished product. The foundations are often supported by concrete piles and connected together. These systems improve productivity, especially in adverse weather conditions, and reduces the amount of excavation required - particularly advantageous when dealing with contaminated ground

Defining Work Tasks

At the same time that the choice of technology and general method are considered, a parallel step in the planning process is to define the various work tasks that must be accomplished. These work tasks represent the necessary framework to permit *scheduling* of construction activities, along with estimating the *resources* required by the individual work tasks.
The *scheduling problem* is to determine an appropriate set of activity start time, resource allocations and completion times that will result in completion of the project in a timely and efficient fashion. Construction planning is the necessary fore-runner to scheduling. In this planning, defining work tasks, technology and construction method is typically done either simultaneously or in a series of iterations.

The definition of appropriate work tasks can be a laborious and tedious process, yet it represents the necessary information for application of formal scheduling procedures. Since construction projects can involve thousands of individual work tasks, this definition phase can also be expensive and time consuming. Fortunately, many tasks may be repeated in different parts of the project. For example, the tasks involved in the construction of a building floor may be repeated with only minor differences for each of the floors in the building. So It will lead to reduce in time and cost.

While repetition of activities in different locations or reproduction of activities from past projects reduces the work involved, there are very few computer aids for the process of defining activities.

The time required to perform an activity is called the *duration* of the activity. The beginning and the end of activities are signposts or *milestones*, indicating the progress of the project. Occasionally, it is useful to define activities which have no duration to mark important events. For example, receipt of equipment on the construction site may be defined as an activity since other activities would depend upon the equipment availability and the project manager might appreciate formal notice of the arrival. Similarly, receipt of regulatory approvals would also be specially marked in the project plan.

Most of the activities have some sub tasks. It is also required to be executed carefully.

- Transport forms from on-site storage and unload onto the cleaning station.
- Position forms on the cleaning station.
- Wash forms with water.
- Clean concrete debris from the form's surface.
- Coat the form surface with an oil release agent for the next use.
- Unload the form from the cleaning station and transport to the storage location.

This detailed task breakdown of the activity "clean concrete forms" would not generally be done in standard construction planning, but it is essential in the process of programming or designing a *robot* to undertake this activity since the various specific tasks must be well defined for a robot implementation. More detailed task definitions permit better control and more realistic scheduling.

Example: Task Definition for a residential building construction Project

- Excavation and timbering
- Foundations
- Concrete floors
- Reinforced concrete frames
- Roofs
- Brickwork
- Internal fixtures and Fittings
- Insulation
- Plumbing and wiring
- Painting and decorating

Defining Precedence Relationships among Activities

Once work activities have been defined, the relationships among the activities can be specified. *Precedence* relations between activities signify that the activities must take place in a particular sequence. Numerous natural sequences exist for construction activities due to requirements for structural integrity, regulations, and other technical requirements. For example, design drawings cannot be checked before they are drawn. Diagrammatically, precedence relationships can be illustrated by a *network* or *graph* in which the activities are represented by arrows as in Figure. The arrows in Figure are called *branches* or *links* in the *activity network*, while the circles marking the beginning or end of each arrow are called *nodes* or *events*. In this figure, links represent particular activities, while the nodes represent milestone events.

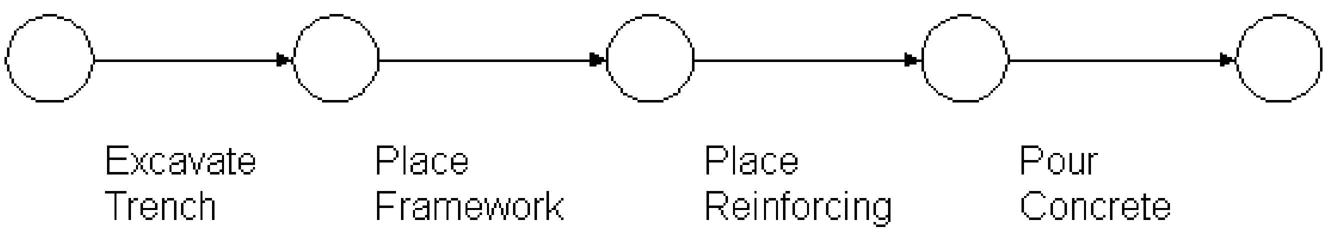


Figure Illustrative Set of Four Activities with Precedence

More complicated precedence relationships can also be specified. For example, one activity might not be able to start for several days after the completion of another activity. As a common example, concrete might have to cure (or set) for several days before formwork is removed. This restriction on the removal of forms activity is called a *lag* between the completion of one activity (i.e., pouring concrete in this case) and the start of another activity (i.e., removing formwork in this case). Many computers based scheduling programs permit the use of a variety of precedence relationships.

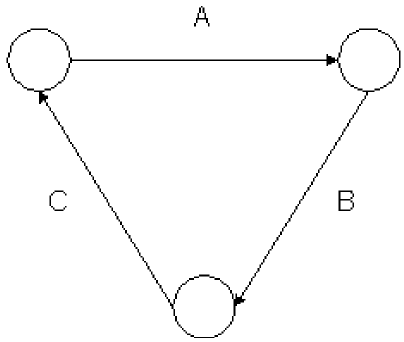


Figure Example of an Impossible Work Plan

Forgetting a necessary precedence relationship can be more dangerous. For example, suppose that installation of dry wall should be done prior to floor finishing. Ignoring this precedence relationship may result in both activities being scheduled at the same time. Corrections on the spot may result in increased costs or problems of quality in the completed project.

Unfortunately, there are few ways in which precedence omissions can be found other than with checks by knowledgeable managers or by comparison to comparable projects. One other possible but little used mechanism for checking precedence is to conduct a physical or computer based simulation of the construction process and observe any problems.

Finally, it is important to realize that different types of precedence relationships can be defined and that each has different implications for the schedule of activities:

- Some activities have a necessary technical or physical relationship that cannot be superseded. For example, concrete pours cannot proceed before formwork and reinforcement are in place.
- Some activities have a necessary precedence relationship over a continuous space rather than as discrete work task relationships. For example, formwork may be placed in the first part of an excavation trench even as the excavation equipment continues to work further along in the trench. Formwork placement cannot proceed further than the excavation, but the two activities can be started and stopped independently within this constraint.
- Some "precedence relationships" are not technically necessary but are imposed due to implicit decisions within the construction plan. For example, two activities may require the same piece of equipment so a precedence relationship might be defined between the two to insure that they are not scheduled for the same time period. Which activity is scheduled first is arbitrary. As a second example, reversing the sequence of two activities may be technically possible but more expensive. In this case, the precedence relationship is not physically necessary but only applied to reduce costs as perceived at the time of scheduling.

Example: Precedence Definition for Site Preparation and Foundation Work

Suppose that a site preparation and concrete slab foundation construction project consists of nine different activities:

A. Site clearing
B. Removal of trees,
C. General excavation,
D. Grading general area,
E. Excavation for utility trenches,
F. Placing formwork and reinforcement for concrete,
G. Installing sewer lines,
H. Installing other utilities,
I. Pouring concrete.

Activities A (site clearing) and B (tree removal) does not have preceding activities since they depend on none of the other activities. We assume that activities C (general excavation) and D (general grading) are preceded by activity A (site clearing). It might also be the case that the planner wished to delay any excavation until trees were removed, so that B (tree removal) would be a precedent activity to C (general excavation) and D (general grading). Activities E (trench excavation) and F (concrete preparation) cannot begin until the completion of general excavation and tree removal, since they involve subsequent excavation and trench preparation. Activities G (install lines) and H (install utilities) represents installation in the utility trenches and cannot be attempted until the trenches are prepared, so that activity E (trench excavation) is a preceding activity. We also assume that the utilities should not be installed until grading is completed to avoid equipment conflicts, so activity D (general grading) is also preceding activities G (install sewers) and H (install utilities). Finally, activity I (pour concrete) cannot begin until the sewer line is installed and formwork and reinforcement are ready, so activities F and G are preceding. Other utilities may be routed over the slab foundation, so activity H (install utilities) is not necessarily a preceding activity for activity I (pour concrete). The result of our planning is the immediate precedence shown in Table

TABLE Precedence Relations for a Nine-Activity Project Example

Activity	Description	Precedence relationship
A	Site clearing	---
B	Removal of trees	---
C	General excavation	A
D	Grading general area	A
E	Excavation for utility trenches	B,C
F	Placing formwork and reinforcement for concrete	B,C
G	Installing sewer lines	D,E
H	Installing other utilities	D,E
I	Pouring concrete	F,G

The network representations of activities can also be very helpful in visualizing the various activities and their relationships for a project.

Estimating Activity Durations

Estimate Activity Durations is the **process** of **estimating** the number of work periods needed to complete individual **activities** with **estimated** resources. The key benefit of this **process** is that it provides the amount of time each **activity** will take to complete, which is a major input into the Develop Schedule **process**.

The aim of effective project management is to bring the project to completion on time and on schedule. Estimating project duration is a key function of scheduling. Individual activities make up the schedule, and the estimates of their duration determine the project timetable

Six Methods for the Estimation of Activity Duration in Project Management

1. Work Breakdown

Sometimes an activity is too large or complex for a reliable duration estimate. Project guidelines state that an individual activity that takes up more than 10 percent of the project schedule has to be broken down. A project manager uses a work breakdown technique to reduce the activity to smaller tasks. Ideally, the project manager can estimate the duration of tasks that individual workers perform more accurately than the whole activity.

2. Historical

An effective way of estimating activity duration is to use historical data. If data on the duration of the same activities is available, project managers take the average duration of the historical records and use that in the project schedule. For small businesses which have not completed many projects, other methods are preferable.

3. Analogy

Use of analogous activities can generate reliable estimates. If the company has carried out a similar activity, it may be possible to adapt the duration to the current case. Project managers have to study the similarities of the two activities and adjust for any features that may result in differences in duration. Even small businesses can often find such similar activities on which to base estimates.

4. Expert Judgment

If expert judgment is available at reasonable cost, a project manager will often use such duration estimates as superior to internally generated ones. Expert judgment means using specialists who have a reputation for knowledge of the particular field and experience in estimating activity duration within it.

5. Effort

A project manager who knows what resources are necessary for an activity may calculate the effort the activity requires and arrive at duration. He adds the amount of time it takes to obtain materials to the labor time it takes to complete the tasks. Such an estimate has the advantage that it allows the project manager to track resource use and compare it to the estimate.

6. Units

Calculation based on units of activity is a method available to both the largest and smallest businesses. Typical units are numbers of products or size of the product. Project managers can calculate how much time it took to produce a certain number or a certain size and adjust for the number or size they want to produce. Project managers have to adjust for economies of scale for these calculations.

The Inputs, Tools & Techniques, and Outputs are:

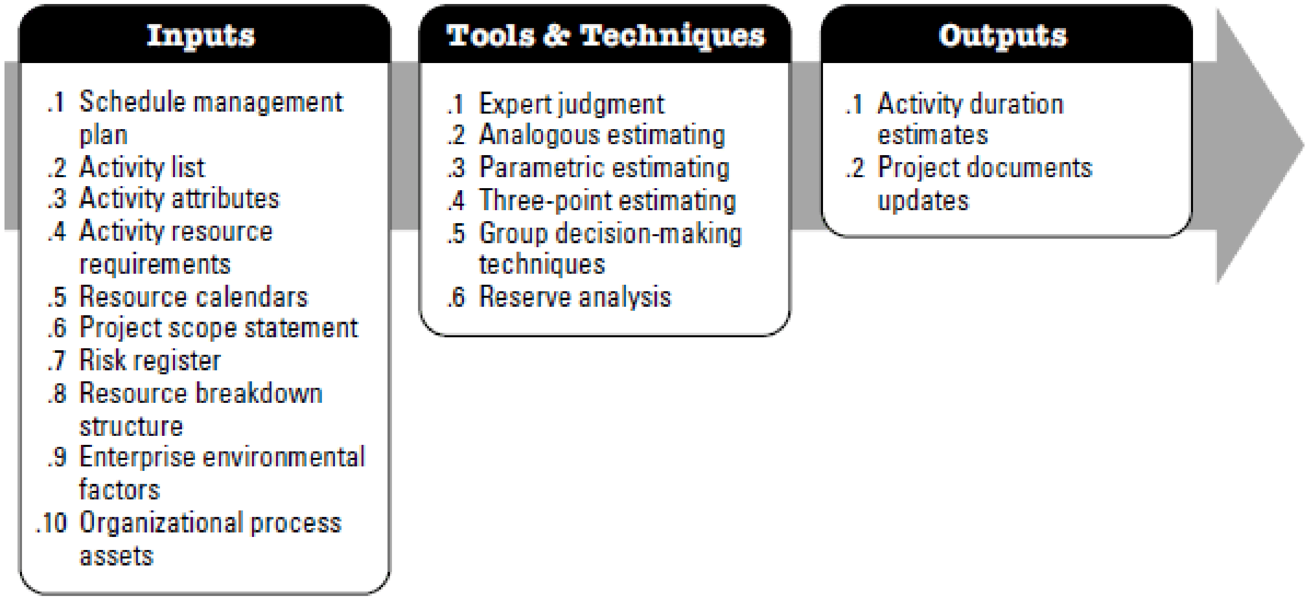


Fig. Estimate activity duration----Inputs, Tools & Techniques and Outputs

Activity Resource Estimating

Estimate Activity Resources is the process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity.

The main purpose of this process is to

• Estimate the types of resources needed for a given activity
• Estimate the quantities of each type of resource needed for the activity

The following steps are involved in activity resource estimation

1. **Reviewing resource availability:** Some of the needed project resources might not be present in your company. For instance, for a niche software development project requiring a specific set of skills, your company might not have any software developer meeting the requirements. In this case, alternatives such as outsourcing the required resource or hiring a new software developer must be planned during estimate activity resources process.

2. **Reviewing WBS and activity list:** Since activity resources will be estimated for the project activities, and these activities belong to the WBS and part of activity list, WBS and activity list must be reviewed during the Estimate Activity Resource Process. And necessary resource estimations will be done for each activity in the activity list respectively.

3. **Identifying potentially available resources:** If it is possible to allocate who will do a specific project activity, these must be identified during estimate activity resources process.

4. **Reviewing historical info about reuse of resources:** If there had been a similar project in the organization, that would be very useful for you to check what kind of resources have been used. Because, most probably, you will use similar resources in your project as well.

5. **Reviewing organizational policies on resource usage:** There might be policies and guidelines on how to request a resource, how to assign a task, how to monitor etc. For instance, many corporate companies use PPM tool of HP. This tool helps to monitor project phases, assign activities to project team members and time reporting. These kinds of organizational policies on resource usage must be followed during the estimate activity resources process.

6. **Expert judgment on what resources are needed and available:** Based on the project activities, what kind of competence and experience must be looked in the project team member candidates can be obtained from subject matter experts. Then the outputs of the experts will guide you on how to form project team respectively.

7. **Analysis of alternatives whether they are better to utilize resources:** For instance, if you will need a graphic designer for your project and this team member will work only 2 days a week, it won't be a good solution to dedicate this resource completely on the project. This can be outsourced to a vendor and required work might be acquired from them respectively. This will be less costly than hiring a new graphic designer or dedicating a resource 100% on the project.

8. **Make or buy decisions are taken during estimate activity resources process:** Let's assume that you need a crane for your construction project and you will need this only for 2 months and this is not a tool that your company uses in other projects. If the cost of the crane is 500,000 and rental cost of the crane for 2 months is 100,000, it will be a good decision to rent the crane. These kinds of make or buy decisions are taken during estimate activity resources process.

9. **Breaking down the activity further if it is still complex to estimate:** Although WBS is created and activity list is composed, some activities might be still large enough to estimate. In this case, a further breakdown of an activity can be done during the Estimate Activity Resources process.

10. **Quantify resource requirements by activity:** If you are managing a software project, you know that you will need analysts, software architects, software engineers, testers etc. But do you know how many from each of these roles you will need? Estimate activity resources process will help to quantify resource requirements by activity.

11. **Create a hierarchical structure of resources:** Actually, this is Resource Breakdown Structure and abbreviated as RBS. For instance, if you have 4 software engineers in the software project and 3 of them are reporting to one lead software engineer, this must be highlighted during estimate activity resources process.

12. **Develop a plan as to what type of resources will be used:** As we expressed already, roles you need in the project team, their hierarchy, skills, and competence must be highlighted during estimate activity resources process.

13. **Update project documents:** As in many other processes, activities done in the estimate activity resources process require an update of project documents as well.

Coding Systems

One objective in many construction planning efforts is to define the plan within the constraints of a universal *coding system* for identifying activities. Each activity defined for a project would be identified by a pre-defined code specific to that activity. The use of a common nomenclature or identification system is basically motivated by the desire for better integration of organizational efforts and improved information flow. In particular, coding systems are adopted to provide a numbering system to replace verbal descriptions of items. These codes reduce the length or complexity of the information to be recorded. A common coding system within an organization also aids consistency in definitions and categories between projects and among the various parties involved in a project. Common coding systems also aid in the retrieval of historical records of cost, productivity and duration on particular activities. Finally, electronic data storage and retrieval operations are much more efficient with standard coding systems

UNIT-IV

Quality Control and Safety during Construction

Quality control and safety represent increasingly important factor for project managers. Defects or failures in constructed facilities can result in very large costs. Even with minor defects, re-construction may be required and facility operations impaired. Increased costs and delays are the result. In the worst case, failures may cause personal injuries or fatalities. Accidents during the construction process can similarly result in personal injuries and large costs. Indirect costs of insurance, inspection and regulation are increasing rapidly due to these increased direct costs. Good project managers try to ensure that the job is done right the first time and that no major accidents occur on the project.

As with cost control, the most important decisions regarding the quality of a completed facility are made during the design and planning stages rather than during construction. It is during these preliminary stages that component configurations, material specifications and functional performance are decided. Quality control during construction consists largely of insuring *conformance* to these original designs and planning decisions.

While conformance to existing design decisions is the primary focus of quality control, there are exceptions to this rule. First, unforeseen circumstances, incorrect design decisions or changes desired by an owner in the facility function may require re-evaluation of design decisions during the course of construction. While these changes may be motivated by the concern for quality, they represent occasions for re-design with all the attendant objectives and constraints. As a second case, some designs rely upon informed and appropriate decision making during the construction process itself. For example, some tunneling methods make decisions about the amount of shoring required at different locations based upon observation of soil conditions during the tunneling process. Since such decisions are based on better information concerning actual site conditions, the facility design may be more cost effective as a result.

With the attention to conformance as the measure of quality during the construction process, the specification of quality requirements in the design and contract documentation becomes extremely important. Quality requirements should be clear and verifiable, so that all parties in the project can understand the requirements for conformance. Much of the discussion in this chapter relates to the development and the implications of different quality requirements for construction as well as the issues associated with insuring conformance.

Safety during the construction project is also influenced in large part by decisions made during the planning and design process. Some designs or construction plans are inherently difficult and dangerous to implement, whereas other, comparable plans may considerably reduce the possibility of accidents. For example, clear separation of traffic from construction zones during roadway rehabilitation can greatly reduce the possibility of accidental collisions. Beyond these design decisions, safety largely depends upon education, vigilance and cooperation during the construction process. Workers should be constantly alert to the possibilities of accidents and avoid taken unnecessary risks.

Organizing for Quality and Safety

A variety of different organizations are possible for quality and safety control during construction. One common model is to have a group responsible for quality assurance and another group primarily responsible for safety within an organization. In large organizations, departments dedicated to quality assurance and to safety might assign specific individuals to assume responsibility for these functions on particular projects. For smaller projects, the project manager or an assistant might assume these and other responsibilities. In either case, insuring safe and quality construction is a concern of the project manager in overall charge of the project in addition to the concerns of personnel, cost, time and other management issues.

Inspectors and quality assurance personnel will be involved in a project to represent a variety of different organizations. Each of the parties directly concerned with the project may have their own quality and safety inspectors, including the owner, the engineer/architect, and the various constructor firms. These inspectors may be contractors from specialized quality assurance organizations. In addition to on-site inspections, samples of materials will commonly be tested by specialized laboratories to insure compliance. Inspectors to insure compliance with regulatory requirements will also be involved. Common examples are inspectors for the local government's building department, for environmental agencies, and for occupational health and safety agencies.

The Occupational Safety and Health Administration (OSHA) routinely conduct site visits of work places in conjunction with approved state inspection agencies. OSHA inspectors are required by law to issue citations for all standard violations observed. Safety standards prescribe a variety of mechanical safeguards and procedures; for example, ladder safety is covered by over 140 regulations. In cases of extreme non-compliance with standards, OSHA inspectors can stop work on a project. However, only a small fraction of construction sites are visited by OSHA inspectors and most construction site accidents are not caused by violations of existing standards. As a result, safety is largely the responsibility of the managers on site rather than that of public inspectors.

While the multitude of participants involved in the construction process require the services of inspectors, it cannot be emphasized too strongly that inspectors are only a formal check on quality control. Quality control should be a primary objective for all the members of a project team. Managers should take responsibility for maintaining and improving quality control. Employee participation in quality control should be sought and rewarded, including the introduction of new ideas. Most important of all, quality improvement can serve as a catalyst for improved productivity. By suggesting new work methods, by avoiding rework, and by avoiding long term problems, good quality control can pay for itself. Owners should promote good quality control and seek out contractors who maintain such standards.

In addition to the various organizational bodies involved in quality control, issues of quality control arise in virtually all the functional areas of construction activities. For example, insuring accurate and useful information is an important part of maintaining quality performance. Other aspects of quality control include document control (including changes during the construction process), procurement, field inspection and testing, and final checkout of the facility.

Note: Write any organizations or Associations which inspect the construction work to ensure quality and safety (eg. Duties of PWD, Environment health and safety organization)

Work and Material Specifications

Specifications of work quality are an important feature of facility designs. Specifications of required quality and components represent part of the necessary documentation to describe a facility. Typically, this documentation includes any special provisions of the facility design as well as references to generally accepted specifications to be used during construction.

CPWD Specifications, 2009 will replace existing CPWD Specifications, 1996 along with correction slips. The specifications of many items have been updated and improved by making them more comprehensive. Specifications of items, which have become obsolete over a period of time or are not in use, have been deleted. Many new items using new materials and latest technology have also been added.

The Work shall be carried out according to these Specifications whether specifically mentioned elsewhere or not. No extra in any form will be paid unless it is definitely stated as an item in the Bill of Quantities. Whenever the Specifications are not given or when the Specifications are ambiguous, the relevant Nepal Standards or Indian Standards and further amendments will be considered as final and binding. All Works shall be carried out simultaneously with electrical, plumbing, sanitary and other services and in co-operation with the Contractors of the above services. The Work shall be carried on till it is completed satisfactorily along with the completion of other essential services. The building Contractor shall keep the other Contractors informed of the proposed program of Work, well in advance, so that the building Work is not hindered. The Contractor shall further cooperate with other Contractors in respect of any facility required by them e.g. making holes in shuttering for sanitary, pipes, electric conduits, fan hook etc. However, no extra payment shall be admissible for such reasonable assistance and facilities afforded to other Contractors and the building Contractors shall be deemed to have taken these factors into consideration while quoting the rates. The Work shall be related to the drawings which the Contractor is presumed to have studied. Nothing extra will be paid for any item because of its shape, location or other difficult circumstances, even if the schedule makes no distinction, as long as the item is shown in the drawings. The sources of materials stated in the Specifications are those from which materials are generally available. However, materials not conforming to Specifications shall be rejected even if they come from the stated sources. The Contractor should satisfy himself that sufficient quantity of materials of acceptable Specification is available form the stated or other sources.

Note: **Write some of the code books and its specifications**

Total Quality Control

Quality control in construction typically involves insuring compliance with minimum standards of material and workmanship in order to insure the performance of the facility according to the design. These minimum standards are contained in the specifications. For the purpose of insuring compliance, random samples and statistical methods are commonly used as the basis for accepting or rejecting work completed and batches of materials. Rejection of a material is based on non-conformance or violation of the relevant design specifications. Procedures for this quality control practice are described in the following sections.

An implicit assumption in these traditional quality control practices is the view of an *acceptable quality level* which is an allowable fraction of defective items. Materials obtained from suppliers or work performed by an organization is inspected and passed as acceptable if the estimated defective percentage is within the acceptable quality level. Problems with materials or goods are corrected after delivery of the product.

In contrast to this traditional approach of quality control is the goal of *total quality control*. In this system, no defective items are allowed anywhere in the construction process. While the zero defects goal can never be permanently obtained, it provides a goal so that an organization is never satisfied with its quality control program even if defects are reduced by substantial amounts year after year. This concept and approach to quality control was first developed in manufacturing firms in Japan and Europe, but has since spread to many construction companies. The best known formal certification for quality improvement is the International Organization for Standardization's ISO 9000 standard. ISO 9000 emphasizes good documentation, quality goals and a series of cycles of planning, implementation and review.

Total quality control is a commitment to quality expressed in all parts of an organization and typically involves many elements. Design reviews to insure safe and effective construction procedures are a major element. Other elements include extensive training for personnel, shifting the responsibility for detecting defects from quality control inspectors to workers, and continually maintaining equipment. Worker involvement in improved quality control is often formalized in *quality circles* in which groups of workers meet regularly to make suggestions for quality improvement. Material suppliers are also required to insure zero defects in delivered goods. Initially, all materials from a supplier are inspected and batches of goods with any defective items are returned. Suppliers with good records can be certified and not subject to complete inspection subsequently.

The traditional microeconomic view of quality control is that there is an "optimum" proportion of defective items. Trying to achieve greater quality than this optimum would substantially increase costs of inspection and reduce worker productivity. However, many companies have found that commitment to total quality control has substantial economic benefits that had been unappreciated in traditional approaches. Expenses associated with inventory, rework, scrap and warranties were reduced. Worker enthusiasm and commitment improved. Customers often appreciated higher quality work and would pay a premium for good quality. As a result, improved quality control became a competitive advantage.

Of course, total quality control is difficult to apply, particular in construction. The unique nature of each facility, the variability in the workforce, the multitude of subcontractors and the cost of making necessary investments in education and procedures make programs of total quality control in construction difficult. Nevertheless, a commitment to improved quality even without endorsing the goal of zero defects can pay real dividends to organizations.

Example: Experience with Quality Circles

Quality circles represent a group of five to fifteen workers who meet on a frequent basis to identify, discuss and solve productivity and quality problems. A circle leader acts as mediator between the workers in the group and upper levels of management.

Eg: On a highway project under construction, it was found that the loss rate of ready-mixed concrete was too high. A quality circle composed of cement masons found out that the most important reason for this was due to an inaccurate checking method. By applying the circle's recommendations, the loss rate was reduced.

Quality Control by Statistical Methods *(Testing the prototype)*

An ideal quality control program might test all materials and work on a particular facility. For example, non-destructive techniques such as x-ray inspection of welds can be used throughout a facility. An on-site inspector can witness the appropriateness and adequacy of construction methods at all times. Even better, individual craftsmen can perform continuing inspection of materials and their own work. Exhaustive or 100% testing of all materials and work by inspectors can be exceedingly expensive, however. In many instances, testing requires the destruction of a material sample, so exhaustive testing is not even possible. As a result, small samples are used to establish the basis of accepting or rejecting a particular work item or shipment of materials. Statistical methods are used to interpret the results of test on a small sample to reach a conclusion concerning the acceptability of an entire *lot* or batch of materials or work products.

The use of statistics is essential in interpreting the results of testing on a small sample. Without adequate interpretation, small sample testing results can be quite misleading. As an example, suppose that there are ten defective pieces of material in a lot of one hundred. In taking a sample of five pieces, the inspector might not find *any* defective pieces or might have *all* sample pieces defective. Drawing a direct inference that none or all pieces in the population are defective on the basis of these samples would be incorrect. Due to this random nature of the sample selection process, testing results can vary substantially. It is only with statistical methods that issues such as the chance of different levels of defective items in the full lot can be fully analyzed from a small sample test.

There are two types of statistical sampling which are commonly used for the purpose of quality control in batches of work or materials:

1. The acceptance or rejection of a lot is based on the number of defective (bad) or no defective (good) items in the sample. This is referred to as *sampling by attributes*.
2. Instead of using defective and no defective classifications for an item, a quantitative quality measure or the value of a measured variable is used as a

quality indicator. This testing procedure is referred to as *sampling by variables*.

Whatever sampling plan is used in testing, it is always assumed that the samples are representative of the entire population under consideration. Samples are expected to be chosen randomly so that each member of the population is equally likely to be chosen. Convenient sampling plans such as sampling every twentieth piece, choosing a sample every two hours, or picking the top piece on a delivery truck may be adequate to insure a random sample if pieces are randomly mixed in a stack or in use. However, some convenient sampling plans can be inappropriate. For example, checking only easily accessible joints in a building component is inappropriate since joints that are hard to reach may be more likely to have erection or fabrication problems.

Another assumption implicit in statistical quality control procedures is that the quality of materials or work is expected to vary from one piece to another. This is certainly true in the field of construction. While a designer may assume that all concrete is exactly the same in a building, the variations in material properties, manufacturing, handling, pouring, and temperature during setting insure that concrete is actually heterogeneous in quality. Reducing such variations to a minimum is one aspect of quality construction. Insuring that the materials actually placed achieve some minimum quality level with respect to average properties or fraction of defectives is the task of quality control.

Statistical Quality Control with Sampling by Attributes

Sampling by attributes is a widely applied quality control method. The procedure is intended to determine whether or not a particular group of materials or work products is acceptable. In the literature of statistical quality control, a group of materials or work items to be tested is called a *lot* or *batch*. An assumption in the procedure is that each item in a batch can be tested and classified as either acceptable or deficient based upon mutually acceptable testing procedures and acceptance criteria. Each lot is tested to determine if it satisfies a minimum acceptable quality level (AQL) expressed as the maximum percentage of defective items in a lot or process.

In its basic form, sampling by attributes is applied by testing a pre-defined number of sample items from a lot. If the number of defective items is greater than a trigger level, then the lot is rejected as being likely to be of unacceptable quality. Otherwise, the lot is accepted. Developing this type of *sampling plan* requires consideration of probability, statistics and acceptable risk levels on the part of the supplier and consumer of the lot. Refinements to this basic application procedure are also possible. For example, if the number of defectives is greater than some pre-defined number, then additional sampling may be started rather than immediate rejection of the lot. In many cases, the trigger level is a single defective item in the sample. In the remainder of this section, the mathematical basis for interpreting this type of sampling plan is developed.

More formally, a lot is defined as acceptable if it contains a fraction p_1 or less defective items. Similarly, a lot is defined as unacceptable if it contains a fraction p_2 or more defective units. Generally, the acceptance fraction is less than or equal to the rejection fraction, $p_1 \leq p_2$, and the two fractions are often equal so that there is no ambiguous range of lot acceptability between p_1 and p_2. Given a sample size and a trigger level for lot rejection or acceptance, we would like to determine the probabilities that acceptable lots might be incorrectly rejected (termed *producer's risk*) or that deficient lots might be incorrectly accepted (termed *consumer's risk*).

Consider a lot of finite number N, in which m items are defective (bad) and the remaining (N-m) items are non-defective (good). If a random sample of n items is taken from this lot, then we can determine the probability of having different numbers of defective items in the sample. With a pre-defined acceptable number of defective items, we can then develop the probability of accepting a lot as a function of the sample size, the allowable number of defective items, and the actual fraction of defective items.

Statistical Quality Control with Sampling by Variables

As described in the previous section, sampling by attributes is based on a classification of items as *good* or *defective*. Many work and material attributes possess continuous properties, such as strength, density or length. With the sampling by attributes procedure, a particular level of a variable quantity must be defined as acceptable quality. More generally, two items classified as *good* might have quite different strengths or other attributes. Intuitively, it seems reasonable that some "credit" should be provided for exceptionally good items in a sample. Sampling by variables was developed for application to continuously measurable quantities of this type. The procedure uses measured values of an attribute in a sample to determine the overall acceptability of a batch or lot. Sampling by variables has the advantage of using more information from tests since it is based on actual measured values rather than a simple classification. As a result, acceptance sampling by variables can be more efficient than sampling by attributes in the sense that fewer samples are required to obtain a desired level of quality control.

In applying sampling by variables, an acceptable lot quality can be defined with respect to an upper limit U, a lower limit L, or both. With these boundary conditions, an acceptable quality level can be defined as a maximum allowable fraction of defective items.

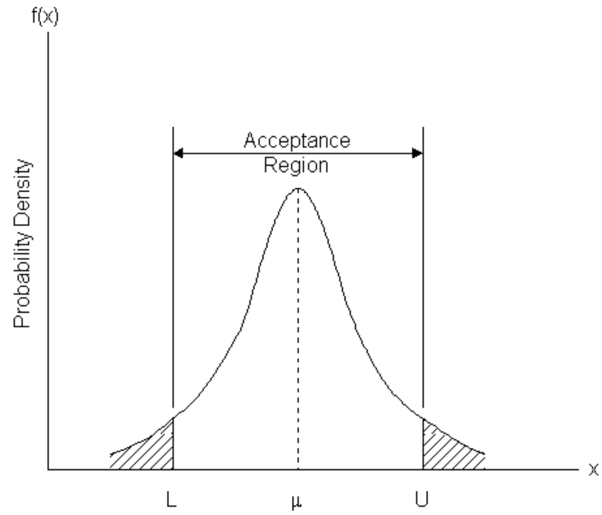


Figure Variable Probability Distributions and Acceptance Regions

In sampling by variables, the fraction of defective items is estimated by using measured values from a sample of items. As with sampling by attributes, the procedure assumes a random sample of a give size is obtained from a lot or batch. In the application of sampling by variables plans, the measured characteristic is virtually always assumed to be *normally distributed* as illustrated in Figure . The normal distribution is likely to be a reasonably good assumption for many measured characteristics such as material density or degree of soil compaction. The Central Limit Theorem provides a general support for the assumption: if the source of variations is a large number of small and independent random effects, then the resulting distribution of values will approximate the normal distribution. If the distribution of measured values is not likely to be approximately normal, then sampling by attributes should be adopted. Deviations from normal distributions may appear as *skewed* or non-symmetric distributions, or as distributions with fixed upper and lower limits.

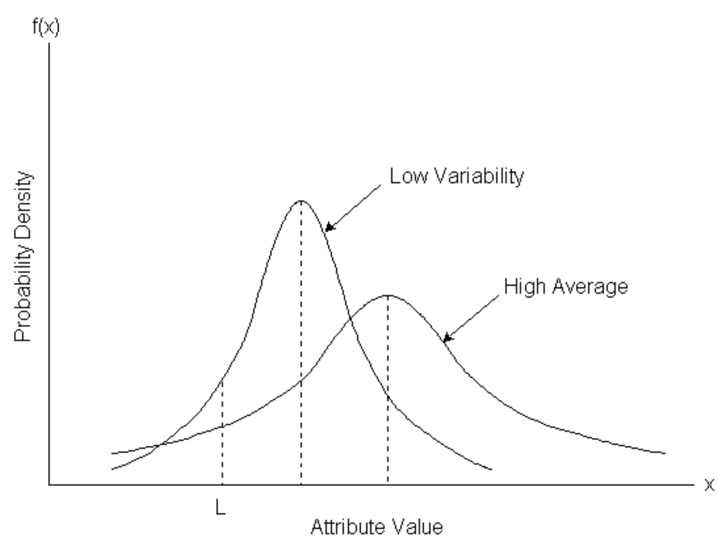


Figure Testing for Defective Component Strengths

Safety

Various measures are available to improve site safety in construction. Several of the most important occur before construction is undertaken. These include design, choice of technology and education. By altering facility designs, particular structures can be safer or more hazardous to construct. For example, parapets can be designed to appropriate heights for construction worker safety, rather than the minimum height required by building codes.

Choice of technology can also be critical in determining the safety of a jobsite. Safeguards built into machinery can notify operators of problems or prevent injuries. For example, simple switches can prevent equipment from being operating when protective shields are not in place. With the availability of on-board electronics (including computer chips) and sensors, the possibilities for sophisticated machine controllers and monitors has greatly expanded for construction equipment and tools. Materials and work process choices also influence the safety of construction. For example, substitution of alternative materials for asbestos can reduce or eliminate the prospects of long term illnesses such as *asbestoses*.

Educating workers and managers in proper procedures and hazards can have a direct impact on jobsite safety. The realization of the large costs involved in construction injuries and illnesses provides a considerable motivation for awareness and education. Regular safety inspections and safety meetings have become standard practices on most job sites.

Pre-qualification of contractors and sub-contractors with regard to safety is another important avenue for safety improvement. If contractors are only invited to bid or enter negotiations if they have an acceptable record of safety (as well as quality performance), then a direct incentive is provided to insure adequate safety on the part of contractors.

During the construction process itself, the most important safety related measures are to insure vigilance and cooperation on the part of managers, inspectors and workers. Vigilance involves considering the risks of different working practices. In also involves maintaining temporary physical safeguards such as barricades, braces, railings, toe boards and the like. Sets of standard practices are also important, such as:

- Requiring hard hats on site.
- Requiring eye protection on site.
- Requiring hearing protection near loud equipment.

- Insuring safety shoes for workers.
- providing first-aid supplies and trained personnel on site

While eliminating accidents and work related illnesses is a worthwhile goal, it will never be attained. Construction has a number of characteristics making it inherently hazardous. Large forces are involved in many operations. The jobsite is continually changing as construction proceeds. Workers do not have fixed worksites and must move around a structure under construction. The tenure of a worker on a site is short, so the worker's familiarity and the employer-employee relationship are less settled than in manufacturing settings. Despite these peculiarities and as a result of exactly these special problems, improving worksite safety is a very important project management concern.

Note: Write any examples of injuries happen during construction because of less precaution for safety

Also you may write any safety measures taken in India during construction to avoid injuries and loses

Needs for inspection in the construction work

Inspections are an essential part of the construction process. If done correctly, they can have tremendous advantages for anyone working in the industry. They can provide the certainty that everything proceeds as it should and in a safe way.

It is clear that inspectors have an essential job. They have to check everything and give a heads up for any violations or mismanagement during the completion of the project. Inspections are very tricky and in the present post, we will try to shed some light on the various pros and cons that they may have for construction.

In general, there are two main types of inspections:

Scheduled Inspections

During a scheduled inspection, things are more straightforward and structured for both sides. An “inspection target” is selected and notified beforehand. The element of surprise isn’t present in such cases. In that sense, the people who are responsible for the project have more time to prepare. The target selection is based on various criteria, such as the location or the accident risk around the project. However, there always are concerns about the neutrality of the choices. Timing is a vital parameter for the success of the inspection.

Random Inspections

Unannounced inspections tend to create more bother, due to the element of surprise that we mentioned before. It’s an excellent way to get a more “sincere” overview of the situation but it can also lead to an inefficient inspection due to the random nature of the whole procedure.

In both cases, timing is a vital element for the success of the inspection. Furthermore, close attention to detail is a must in order for the inspectors to manage reaching to some effective conclusions.

Quality of a constructed facility may be verified based on following factors.

1. Aesthetics
2. Strength
3. Durability
4. Safety
5. Economy
6. Maintainability
7. Reliability
8. Degree of satisfaction of the end user
9. Versatility of use for many purposes

Construction Inspections: The Main Benefits

Safety Planning
Better Task Focus
Construction Quality
Greener Construction
Hazard Identification

Proper Safety Planning

The attention that inspectors invest on safety is a big plus for construction. Identifying the safest road in using equipment and making sure that all the members of your construction project aren't in any kind of danger is priceless. And that's why; inspections should always be one of the main pillars in a construction project.

Hazard Identification

Coupled with the point made above, hazard identification is hands down one of the most mention-worthy pros of construction inspections. If you want for your inspection to have a positive outcome, you have to be fully aware of the various dangers on site. In that manner, you can also be better protected. And that's something that adds great value to the inspector's job.

Better Task Focus

Inspections may be a pain sometimes but they help those who work in a construction site to maintain an alert state of mind. In simple words, this signifies that construction workers and agents have better concentration and clearer focus on what they are doing. What is more, they have all the necessary means for working efficiently given the fact that everyone is living up to the pre-established expectations.

Improved Construction Quality

Inspections can have a very positive impact on the quality of the building structures. Putting together a project context that follows the existing regulations can help significantly in upgrading both its quality and safety. The greater the quality the greater the profit for those involved.

Greener Construction

Last but certainly not least, the beneficial impact of inspections on the environment. At the moment, there are thorough environmental regulations for the construction industry. Inspections are contributing a lot in making construction companies actually follow them. The serious penalties that come as a result of any potential environmental violations have been, through the years, a great ally to the effort for a greener construction industry.

MAJOR ITEMS IN CONSTRUCTION JOB REQUIRING QUALITY CONTROL

Inspections are an essential part of the construction process. If done correctly, they can have tremendous advantages for anyone working in the industry. They can provide the certainty that everything proceeds as it should and in a safe and quality way.

Quality of construction is dependent, to a great extent, on

1. The quality of materials which are used in construction
2. The expertise of workers
3. The technology adopted in construction
4. Number, type and quality of inspections
5. Quality consciousness of people
6. Funds available for construction and quality control
7. Time available for quality control procedures
8. Existence of norms and guidelines for assessing quality of construction of a particular type
9. Experience and expertise of inspectors
10. Quality of design
11. Nature of the construction project

Quality of construction materials should be good. Guidelines should be followed in the assessment of quality of these materials. Some common materials which are used for construction are given below:

1. Cement
2. Fine and coarse aggregates
3. Chemical admixtures
4. Timber
5. Steel
6. Soil of a site
7. Bricks and stones

STAGES OF INSPECTION AND QUALITY CONTROL

1. Earth Work

Stages

1. Measurement of dimensions in different directions in terms of height, width and length
2. Excavation of soil
3. Determination of soil properties
4. Compacting soil

Quality Control Considerations

1. Accurate measurements with precise instruments
2. Use of good equipment
3. Use of standard procedures for testing of soil
4. Use of equipment for compaction

2. Masonry

Stages

1. Measurement of dimensions in different directions in terms of height, width and length
2. Construction of masonry
3. Curing of masonry work

Quality Control Considerations

1. Use of good quality materials
2. Use of right construction procedures and correct bonds
3. Employment of people with experience and expertise
4. Adequate curing of masonry

3. Reinforced Cement Concrete (RCC)

Stages

1. Measurement of dimensions in different directions in terms of height, width and length
2. Creation and installation of formwork
3. Provision of reinforcement
4. Mixing of concrete

5. Casting of concrete
6. Curing of concrete

Quality Control Considerations

1. Use of good quality materials
2. Use of right construction procedures
3. Employment of people with experience and expertise
4. Correct detailing of reinforcement
5. Adequate curing of concrete

4. Sanitary and Water Supply Services

Stages

1. Measurement of dimensions in different directions in terms of length as well as area covered
2. Procurement of sanitary and water supply items
3. Installation of these items correctly
4. Testing of these items

Quality Control Considerations

1. Use of good quality materials and items
2. Use of right construction procedures
3. Employment of people with experience and expertise

5. Electrical Services

Stages

1. Measurement of dimensions in different directions in terms of length as well as area covered
2. Procurement of items
3. Installation of these items correctly
4. Testing of these items

Quality Control Considerations

1. Use of good quality materials and items
2. Use of right connection procedures
3. Employment of people with experience and expertise

The causes of accidents

1. **Falls from Height:** The most common accident is when workers fall from ladders or scaffolding which can cause injuries such as broken bones, fractures
2. Back injuries and also head injuries.
3. Falling Objects/Materials
4. Tripping Hazards
5. Defective Equipment
6. Vehicle Accidents
7. Excessive Noise/Vibrating Tool Hazards
8. **Exposure to Irritants:** The final thing to consider whilst looking at common accidents in construction is to consider contact with irritants either through inhaling gasses or substances such as carbon monoxide or asbestos dust. Some of these irritants can have devastating consequences on your health and life.

Ways to prevent injuries and improve safety include:

1. Management safety
2. Integrate safety as a part of the job
3. Create accountability at all levels
4. Take safety into account during the project planning process
5. Make sure the contractors are pre-qualified for safety
6. Make sure the workers are properly trained in appropriate areas
7. Have a fall protection system
8. Prevent and address substance abuse to employees
9. Make safety a part of everyday conversation
10. Review accidents and near misses, as well as regular inspections
11. Innovative safety training, e.g. adoption of virtual reality in training
12. Replace some of the works by robots (many workers may worry that this will decrease their employment rate)
13. Adoption of Building Information Model(BIM)with three dimensional printing to make the building model first before put into real practice