

Chapter Two: Construction Planning Fundamental

In construction, all projects are constraint bound: a project needs to be finished within a given time period, below a specific budget and to a given quality and standard. Thus, for the project to be realized and labeled as success, it has got to overcome the constraints. The best way construction managers prepare themselves against these constraints is to prepare a thorough plan for the execution of the project.

A plan prepared well before the commencement of construction is instrumental in formulating directions, coordinating functions, setting targets, forecasting resources, budgeting costs, controlling performance and motivating people. On the other hand, not properly setting out the plan in the early phases of a project may have far reaching consequences in crippling the project or its product.

Planning is preparation of alternatives for achieving specified objectives. Items, which need to be adequately planned, include:

- ✓ The identification of specific activities of work required and the inter - relationships b/n those items (precedence relationships)
- ✓ The proper sequencing of the specific activities of work so as to complete the project in the optimum amount of time.
- ✓ The time of delivery of materials and installed equipment.
- ✓ The types, quantities, and duration of construction plant and equipment
- ✓ The classification and numbers of workers needed and the periods of time they will be need
- ✓ The amount and timing of financial assistance that is needed.

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. For example, the extent to which sub-contractors will be used on a project is often determined during construction planning.

Therefore *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.

Forming a construction plan is a highly challenging task. Most people, if you describe a train of events to them, will tell you what the result would be. They can put those events together in their minds, and argue from them that something will come to pass. There are few people, however, who, if you told them a result, would be able to evolve from their own inner consciousness what the steps were which led up to that result. This power is what I mean when I talk of reasoning backward.

As highlighted in the section above, 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.

Like a detective, a planner begins with a result (i.e. a facility design) and must synthesize the steps required to yield this result. Essential aspects of construction planning include the *generation* of required activities, *analysis* of the implications of these activities, and *choice* among the various alternative means of performing activities.

In contrast to a detective discovering a single train of events, however, construction planners also face the normative problem of choosing the best among numerous alternative plans. Moreover, a detective is faced with an observable result, whereas a planner must imagine the final facility as described in the plans and specifications.

Early phases of a project present immense opportunities to add value to the project's output whereas, at the later stages, costs of changes get very

expensive if mistakes are made in the early phases. Thus, project managers should plan their project to the detail possible before rushing into construction.

2.1 Planning Processes

In developing a construction plan, it is common to adopt a primary emphasis on either cost control or on schedule control as illustrated in Fig. 2.1. Some projects are primarily divided into expense categories with associated costs. In these cases, construction planning is cost or expense oriented. Within the categories of expenditure, a distinction is made between costs incurred directly in the performance of an activity and indirectly for the accomplishment of the project. For example, borrowing expenses for project financing and overhead items are commonly treated as indirect costs. For other projects, scheduling of work activities over time is critical and is emphasized in the planning process. In this case, the planner insures that the proper precedence's among activities are maintained and that efficient scheduling of the available resources prevails.

Traditional scheduling procedures emphasize the maintenance of task precedence's (resulting in *critical path scheduling* procedures) or efficient use of resources over time (resulting in *job shop scheduling* procedures). Finally, most complex projects require consideration of cost and scheduling over time, so that planning, monitoring and record keeping must consider both dimensions. In these cases, the integration of schedule and budget information is a major concern.

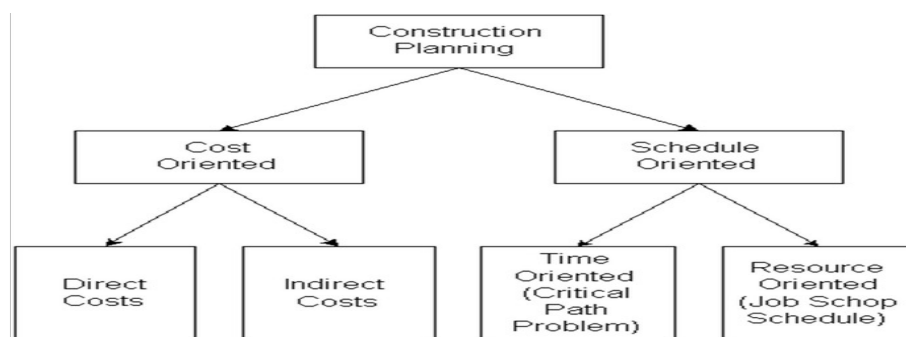


Figure 2.1: Alternative Emphases in Construction Planning

Construction planning as well as scheduling must be done by people who are experienced in and thoroughly familiar with the type of field work involved. It is especially important that those who will be expected to implement the plan in the field have an opportunity to participate in its development. The project network and the management data obtained from it will be realistic and useful only if the job plan is produced and updated by those who understand the job to be done, the ways in which it can be accomplished, and the job site conditions.

The planning process which, under normal circumstances, starts with the client providing the project's terms of reference produces various plans to be used for the proper execution of the project. Table 2.1 below provides that the major project inputs, processes and outputs of project planning in each phases of the project life time/ life cycle.

Concept	Design	Implementation	Commission
Inputs			
Problem or opportunity, project brief, project charter	Approval to go ahead with design and development	Approval to implement project	Commissioning plan, notification of completion
Processes			
Feasibility study	Design product, develop detailed program: WBS, CPM, budget	Solicit tender and award contracts, administer contracts, make the product/solve problem	Start-up and test the product. produce as built drawings, compile knowledge learnt
Outputs			

Feasibility study, Project proposal, Execution strategy	Baseline plan, design drawings and specifications	Completed project output	Project closeout report
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Table 2.1: Project inputs, processes and outputs throughout the life cycle

The following are important stages in construction projects planning processes.

- 1. Division of project:** The project is divided into many divisions depending up on the nature of activity.
- 2. Method of execution:** The method of execution of the project should be decided. i.e either manual or mechanical or both. The method should be economical and less time consuming
- 3. Allocation of time for each activity:** The time for completion of each activity should be decided.
- 4. Material required:** The quantity and quality of material required should be decided. in advance and the time of its delivery at the life.
- 5. Laborer required:** The types of labour i.e. skilled or unskilled, the period for which and the number of labourer required should be clearly stated.
- 6. Completion time:** The date and time required for completion of the work should be known in advance so that necessary arrangement can be made lot to affect the progress of work.

A. Project Planning at the Concept Phase

Project initiation/concept phase aims at formulation of project scope and implementation strategy by project need identification, feasibility studies, investment appraisals, financial appraisal, statutory clearance, project definition; development of strategy for execution (project charter) and finally structuring of project organisation including selection of the project manager (if project is approved for implementation). End of initiation phase marks the

client go-ahead/no-go decision. Project planning at the concept phase include:

- Problem or opportunity, project brief, project charter
- Feasibility study
- Project proposal and Execution strategy

i. Problem or opportunity, project brief, project charter

A project initiation involves the process of formally recognizing that a new project exists [or that an existing project should continue to its next phase]. For the client, this is usually documented in the form of a *project charter*, also known as *terms of reference* (TOR) or *project mission*. Thus project charters are documents [usually supplied by clients] signifying the initiation of a project. A project charter is a tightly worded document outlining what is to be done and the boundaries of the project. For example, most part of charter from a client can be summarized as: to build an 80,000 seator stadium in Addis, to Olympic standards, to be completed six months before the next CAF African Nation's Cup tournament, for X Million birr.

A project charter should generally include:

- Background to the project
- Key assumptions
- Business needs and other commercial needs
- Scope of work
- Identify key activities, budgets and milestones
- Comment on how the project is to be managed

Construction project need arises for various reasons. Some of these need include development of nation's infrastructure, setting-up of an industry, expanding or diversifying the existing activity, meeting the need of the society, investing in real estates and so on. Such identification has to be done with reference to the corporate strategy and country's development strategies keeping in view, the long time economic policy, so that, when completed, it fits well into the total economic system or development networks, capable of being fully utilised. The Government's Planning

Commission and Departments of Economic Affairs and Industrial Development give guidance in these matters. In business, the key to success lies in getting into the right business at the right time. Identification of such opportunities requires:

- *Generation of Ideas:* The search for promising project ideas is the first step towards establishing a successful venture. Barring truly new ideas which are based on significant technological breakthroughs, most of the project ideas involve combining existing fields of technology or offering variants of present products/services. SWOT Analysis can facilitate in stimulating the flow of ideas.
- *Monitoring the Environment:* Basically, a promising investment idea enables a firm (or entrepreneur) to exploit opportunities in the environment by drawing on its competitive strengths.
- *Corporate Appraisal:* A realistic appraisal of corporate strengths and weaknesses is essential for identifying investment opportunities which can be profitably exploited. The broad areas of corporate appraisal and the important aspects to be considered under them include market image, market share, condition and capacity of plant and machinery, location advantage, track record, cash flows and liquidity and dynamism of top management.

ii. Feasibility study

Techno-economic feasibility study is the next stage of the project development phase where the project scope is described, its size and methods determined; suitability of the site, the required natural resources and raw materials investigated and more accurate estimates made of process and non-process equipment, buildings, offsite facilities and other assets, their costs, etc. and the total feasibility of the proposal studied in-depth and cleared. Several institutes have published feasibility study guidelines. These institutions include UNIDO Geneva, the World Bank,

Industrial Development Banks, Planning Commission and so on. The important facets covered in project feasibility analysis are:

- **Market analysis**
- **Technical analysis**
- **Financial analysis**
- **Economic analysis**
- **Ecological analysis**

Market Analysis

It is concerned primarily with aggregate demand and market share.

Technical Analysis:

It seeks to determine whether the prerequisites for the successful commissioning of the project have been considered and reasonably good choices have been made with respect to location, size, process, and so on. The important consideration during technical analysis may include-

- o preliminary investigations, tests and studies done,
- o availability of manpower, raw materials, power, and other inputs,
- o construction methodology,
- o equipment and machines chosen,
- o necessary auxiliary equipments and supplementary works,
- o treatment of effluents,
- o layout of the site, buildings, and plant, and
- o work schedules.

Financial Analysis

It ascertains whether the proposed project will be financially viable in the sense of being able to meet the burden of servicing debt and whether the proposed project will satisfy the return expectations of those who provide the capital. The aspects which have to be looked into while conducting financial appraisal are:

- o Investment outlay and cost of project,
- o Cost of capital,

- o Projected profitability,
- o Break-even point,
- o Cash flows of the project,
- o Projected financial position, and
- o Level of risk.

✶ **Economic Analysis:** It refers to cost benefit analysis which may often be different from its monetary costs and benefits.

✶ **Ecological Analysis:** It is particularly required for major projects which have significant ecological implications like power plants and irrigation schemes, and environmental-polluting industries.

iii. Project proposal and Execution strategy

Information generally contained in the project proposal and executive strategies are as follows:

- o Project background and description,
- o Market and plant capacity,
- o Materials and input,
- o Location and sites,
- o Project engineering and investment cost,
- o Plant organization and overhead cost,
- o Manpower,
- o Implementation schedule, and
- o Financial and economic evaluation.

B. Project Planning at the *Design* Phase

Project planning at the design phase of the construction projects include:

- Approval to go ahead with design and development
- Design product, develop detailed program: WBS, CPM, budget
- Baseline plan, design drawings and specifications

i. Approval to go ahead with design and development

The feasibility report, if found acceptable, is followed up with investment appraisal. The purpose of appraisal is to conduct an objective assessment for investment decision. It involves critical examination of the techno-economic analysis of feasibility findings, with particular reference to:

- Demand analysis,
- Technical specifications feasibility,
- Strength, weaknesses, opportunity and threat (SWOT) analysis,
- Environment's implications,
- Financial analysis, and
- Economic analysis.

Appraisal of feasibility stage enables a client to:

- o decide on the project concept, time and costs;
- o outline the approach needed to taking the project;
- o appoint key persons like construction project manager or project coordinator, to act as his representatives;
- o nominate specialist associated agencies such as the architect, designer and consultants, as per requirements.

Depending upon the nature and complexity of the project, the following may assist the client in making decisions:

- Client representatives: the prospective project manager or his nominee, and the related officials.
- Specialists: the architects, engineers, planners, and finance and management consultants.
- Concerned officials of administration and technical departments.

ii. Design product, develop detailed program

Planning and design phase aims at formulation of plan of actions for coordinating project activities on a time basis so as to achieve specified objectives.

In a typical construction project, planning at the design phase covers the following:

- Basic designs and drawings planning,
- Time planning,
- Cost planning and budgeting,
- Communications planning,
- Quality planning,
- Organisational planning,
- Risk management planning,
- Procurement planning, and
- Project development integrated plan.

In this planning stage, the project manager, assisted by the chief project planner, performs the key development functions..These include to, but are not limited to, the following:

- Participate in the finalisation of design, drawings and specifications so as to formulate construction methodology. ,
- Prepare project execution preliminary plan and formulate the schedule for processing various contracts.
- Advise the client on an early purchase of the items of plant and equipment needing a long lead time for procurement.
- Evolve the pre-tender construction plan for each tender package.
- Scrutinise the tender packages, including drawings and specifications, so as to minimise the discrepancies.
- Conduct the pre-tender briefing to contractors to ensure that the bidders understand the tender documents and the work involved in, each tender.

- Evaluate project costs and compile project budget including preliminary allocations for the various heads of expenditures.
- Compile a project directive covering the scope of work, work plan, organisation, and the policies and procedures for implementing the project

iii. Baseline plan, design drawings and specifications

Design, drawings and specifications define the construction scope of the project. Design forms the base for determining the functional fitness of the proposed facility, development of the drawings, estimation of cost of the project and the quantity of work, deciding construction time and forecasting cash-flow. During the design process, project information is collected, analysed, communicated and recorded for incorporation into the proposed scope of work. Designing follows three sequential processes as given under.

Schematic Design Process: In the project feasibility stage, the designer architect evaluates the client's requirements. After discussing the alternatives with the client, the designer then prepares conceptual design brief for the client's approval, The schematic design brief includes site plan, facility drawings, outlined specifications and conceptual design for structural, electrical, mechanical and other connected systems. This design document may include preliminary sketches, diagrams and other written documents so as to indicate the project scope, time and cost and describe the outline of the construction methodology.

Design Development Process: This phase commences after approval of schematic designs. The emphasis in this phase shifts to details of constructability, system integration and aesthetics. Drawings in this phase include plan, elevation and section of the facility. It also includes the design of the external services. To quote example, some of the designs developed in a housing project are listed below:

- Design of foundation and structure of the buildings,
- Structural design of precast elements of the building,
- External filtered and unfiltered water supply,
- External sewerage system and storm water drain,

- External gas supply,
- External electric services,
- Fire alarm system, and
- Clock system.

Drawings and Specifications Documentation Processes: This process includes preparation of the construction drawings and specifications based on approved designs. The construction drawings and specifications form part of the contracted bids.

Types of Specifications

How the specification is written determines how the contractor will use it. There are many types of specifications, depending on how specific the owner wants to be in instructing the contractor. Here are some of the more common.

Design specification

These are also known as descriptive specifications. They are detailed descriptions of materials, workmanship, installation, and erection procedures. The contractor's obligation is to follow the instructions as laid out in the specifications.

Performance specifications

These layout the expected results of the work and leave the methods to the contractor. Performance may be expressed in a number of ways, depending on the item. For example in terms of operational capacity, functional qualities, appearance, finish, color and so on.

Proprietary specifications

They state exactly the product or the method to be used. Sometimes they may allow for one specific alternate or have an "or equal" clause. The purpose is to ensure that the owner gets a preferred product or method.

Open specifications

These are non restrictive and allow many different choices within set criteria. A number of different manufacturers may be listed, giving contractors great leeway in getting the best price.

C. Project Planning at the *Implementation* Phase

Project planning at the implementation phase of the construction projects include:

- Approval to implement project
- Solicit tender and award contracts, administer contracts, make the product/solve problem
- Completed project output

i. Approval to implement project

At this stage all the construction or contract documents are finalized. The construction documents translate the owner's needs so that the contractor can execute them correctly. They are the communication link among all parties in the project. The standardization of construction documents have evolved through time. Current practice is to bind all the narrative pieces into one document that accompanies the drawings to form the complete package. The package is divided into three general sections –bidding, contractual, and technical –each of which is made up of many subsections. The bid requirements, the agreement, technical specifications, drawings, addenda, and contract modifications all form part of the construction document.

The contract documents under any building projects should include, as a minimum, the following information:

- ❖ **The work to be performed.**
- ❖ **The quality of work required.**
- ❖ **The contractual conditions.**
- ❖ **The cost of finished work.**
- ❖ **The construction program.**

The contract documents on a building contract therefore normally comprise the following:

- 1.** Form of contract Including the articles of agreement and appendix
- 2.** Contract drawings
- 3.** Bill of quantities or specifications

ii. Solicit tender and award contracts, administer contracts, make the product/solve problem

Some of the major activities undertaken at this stage are includes:

1. Tendering

At this stage contractors are invited to offer their best technical and financial offers as per the conditions of contract and specifications depicted in the tender documents.

2. Award of Contract

After the negotiations have been successful, the contract will be awarded to the most responsible bidder.

The owner: - are both financier and the beneficiary of the project he is also interested in an economical, safe and durable structure completely fit for its use.

The owner expects from the consultant an honest advice about the feasibility and soundness of the project.

The owner expects from the contractor to deliver him the project in time, without misunderstanding, friction, expected cost and adequate for its intended use.

Consultant: - is responsible for the economic and safe design and construction of the work under his supervision.

Contractor: - is responsible for procuring materials not supplied by the owner, organizing, planning and execution of the work as per given drawings and specifications lay down in the contract and as per time schedule.

3. Procurement of Materials

This is first and preliminary to all construction works to procure the required materials at site. The engineer should know the type of materials and their quantities required for the work before hand. The material either should be brought at site before starting the work or its regular supply is ensured.

4. Construction and Supervision

Construction and supervision both are complementary to each other. At this stage the construction work (project) is actually executed as per designs.

Some of the problems, raised during the construction, are referred to the designers for evolving appropriate solution. Due to this continuous interaction exists b/n the designers and the contractors throughout the construction stage of the work prepare the construction schedule.

iii. Completed project output

The completion of the construction phase of the project includes certain follow-up actions necessary to ensure that the facility constructed functions satisfactorily. Project close up includes the following tasks:

- Administrative Close,
- Contract Closeout, and
- Lessons Learnt.

For proper closing of project:

- The post-completion maintenance is usually entrusted to an agency familiar with the construction. In most cases, the contractor responsible for construction is given this responsibility for one year after completion; and this aspect is included in the scope of work of the contractor.
- A proper record of the operating instructions and as-built drawings is maintained.
- The staff and workers necessary for operating and maintaining the facility are trained prior to its taking over.
- The site is cleared of the left-outs of the construction and unwanted materials.
- The client fully safeguards his interests prior to rendering the completion certificate to the contractor, and also before making the final payments.

After completion by the contractor, it is the project team of the client that hands over the project to him. The team also prepares a project completion report which includes the scope and schedule of work, the important events, the contract executed, the addresses of the suppliers of materials and equipment, the equipment maintenance manual, the as-built drawings, the

costs involved, the problems encountered during execution, the lessons learned and the minor defects noticed at the time of handing over.

D. Project Planning at the *Commission* Phase

The project planning Outputs in construction projects include:

- Commissioning plan, notification of completion
- Start-up and test the product, Produce as built drawings, compile knowledge learnt
- Project closeout report

This is a significant event for both the owner and the contractor.

- ❖ The acceptance of a completed project is customarily based on a final inspection performed by the owner's representative and conditioned upon the correction of any deficiencies noted.
- ❖ If the facility or a portion thereof is substantially complete, the owner's representative will execute a certificate of substantial completion for the work. The contractor may then require and receive a final progress payment. However, sufficient retain age is withhold to ensure the correction of any remaining deficiencies.
- ❖ Final payment and its acceptance by the contractor usually constitute a waiver of all claims by either the owner or contractor except for unsettled liens and claims and deficiencies falling under warranty provisions.

In most, if not all, construction projects the major processes under this stage are two: Commissioning and Acceptance.

Commissioning is a process whereby the contractor makes sure that all installed electro - mechanical and other parts are operational or functional.

Acceptances: - it includes:

- o **Provisional Acceptance:** - This is avoids of acceptance the completed work on provisional basis for a period of one year.
- o **Final Acceptance:-**At this stage the owner completely accepts the works executed in total and the retention money is released to the contractor.

Contract closeout begins when the contract has been physically complete, i.e., all services have been performed and products delivered. Closeout is completed when all administrative actions have been completed, all disputes settled, and final payment has been made. The process can be simple or complex depending on the contract type for cost-reimbursement contracts. This process requires close coordination between the contracting office, the finance office, the program office, and the contractor. Contract closeout is an important aspect of contract administration.

The contract audit process also affects contract closeout on cost-reimbursement contracts. Contract audits are required to determine the reasonableness, allowability, and allocability of costs incurred under cost reimbursement contracts. Although there is a pre award audit of the contractor's proposal, there is a cost-incurred audit of the contractor's claim of incurred costs and a close out audit to reconcile the contractor's final claim under the contract to incurred costs previously audited. When there is a delay in completing the cost-incurred and closeout audits, contracting officials often cannot complete the closeout process for many cost reimbursement contracts. Although the FAR does allow agencies to use quick closeout procedures (desk reviews) to close some cost reimbursement contracts without a closeout audit, inconsistencies have been noted in the use of the procedures.

It is important that contracting officials have a good working relationship with the agency's auditors and the cognizant audit agency to accomplish contract closeout under cost-reimbursement contracts.

Defining Work Tasks/Work Breakdown Structure

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, and any necessary *precedence's* or required sequence among the tasks. The terms

work "tasks" or "activities" are often used interchangeably in construction plans to refer to specific, defined items of work. In job shop or manufacturing terminology, a project would be called a "job" and an activity called an "operation", but the sense of the terms is equivalent. 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 forerunner 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 facility or past facility construction plans can be used as general models for new projects. 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. Also, standard definitions and nomenclatures for most tasks exist. As a result, the individual planner defining work tasks does not have to approach each facet of the project entirely from scratch.

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. Databases and information systems can assist in the storage and recall of the activities associated with past projects as described in Chapter 14. For the scheduling process itself, numerous computer programs are available. But for the important task of defining activities, reliance on the skill, judgment and experience of the construction planner is likely to continue.

More formally, an *activity* is any subdivision of project tasks. The set of activities defined for a project should be *comprehensive* or completely

exhaustive so that all necessary work tasks are included in one or more activities. Typically, each design element in the planned facility will have one or more associated project activities. Execution of an activity requires time and resources, including manpower and equipment, as described in the next section. 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.

The extent of work involved in any one activity can vary tremendously in construction project plans. Indeed, it is common to begin with fairly coarse definitions of activities and then to further sub-divide tasks as the plan becomes better defined. As a result, the definition of activities evolves during the preparation of the plan. A result of this process is a natural *hierarchy* of activities with large, abstract functional activities repeatedly sub-divided into more and more specific sub-tasks.

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.

It is generally advantageous to introduce an explicit *hierarchy* of work activities for the purpose of simplifying the presentation and development of a schedule. For example, the initial plan might define a single activity associated with "site clearance." Later, this single activity might be sub-divided into "re-locating utilities," "removing vegetation," "grading", etc. However, these activities could continue to be identified as sub-activities under the general activity of "site clearance." This hierarchical structure also facilitates the preparation of summary charts and reports in which detailed operations are combined into aggregate or "super"-activities.

More formally, a hierarchical approach to work task definition decomposes the work activity into component parts in the form of a tree. Higher levels in

the tree represent decision nodes or summary activities, while branches in the tree lead to smaller components and work activities. A variety of constraints among the various nodes may be defined or imposed, including precedence relationships among different tasks as defined below. Technology choices may be *decomposed* to decisions made at particular nodes in the tree.

The number and detail of the activities in a construction plan is a matter of judgment or convention. Construction plans can easily range between less than a hundred to many thousand defined tasks, depending on the planner's decisions and the scope of the project. If subdivided activities are too refined, the size of the network becomes unwieldy and the cost of planning excessive. Sub-division yields no benefit if reasonably accurate estimates of activity durations and the required resources cannot be made at the detailed work breakdown level. On the other hand, if the specified activities are too coarse, it is impossible to develop realistic schedules and details of resource requirements during the project. More detailed task definitions permit better control and more realistic scheduling. It is useful to define separate work tasks for:

- those activities which involve different resources, or
- those activities which do not require continuous performance.

In practice, the proper level of detail will depend upon the size, importance and difficulty of the project as well as the specific scheduling and accounting procedures which are adopted. However, it is generally the case that most schedules are prepared with too little detail than too much. It is important to keep in mind that task definition will serve as the basis for scheduling, for communicating the construction plan and for construction monitoring. Completion of tasks will also often serve as a basis for progress payments from the owner. Thus, more detailed task definitions can be quite useful. But more detailed task breakdowns are only valuable to the extent that the resources required, durations and activity relationships are realistically estimated for each activity.

Providing detailed work task breakdowns is not helpful without a commensurate effort to provide realistic resource requirement estimates. As more powerful, computer-based scheduling and monitoring procedures are introduced, the ease of defining and manipulating tasks will increase, and the number of work tasks can reasonably be expected to expand.

The following are suggested as guidelines for use when activities are being identified.

- By category of work as distinguished by materials such as concrete, timber, steel etc,
- By category of work as distinguished by craft or crew requirements (formworks slab, formwork footings)
- By category of work as distinguished by equipment requirements,
- By area of responsibility. Work items done by the general contractor and each of his sub-contractor should be separated,
- By distinct structural elements such as footings, walls, beams, columns and slabs, etc
- With regard to owner's breakdown of the work for bidding or payment purposes,
- With regard to contractor's breakdown for estimating and cost accounting purposes.

Complex projects consist of numerous smaller, interrelated tasks and work elements. The goals or end item of a project is a system that can be broken down into subsystems, which themselves can be broken down and so on. The procedure for dividing the overall project into sub elements is called Work Breakdown Structure or WBS. The purpose of WBS is to divide the total project into small pieces, sometimes called work packages or work activities. Dividing the project into work packages makes it possible to prepare project schedules and cost estimates and to assign management and task responsibilities.

There are two major forms of WBS presentations:

a. Text indents

1.0.0 A house project

1.1.0 Civil work

1.1.1 Sub structure

1.1.1.1 Clearing

1.1.1.2 Drudging

1.1.1.3 Excavation

1.1.1.4 Rebar fixing

1.1.1.5 Concert casting

1.1.2 Super structure

1.1.2.1

1.2.0 Plumbing

1.2.1 Piping

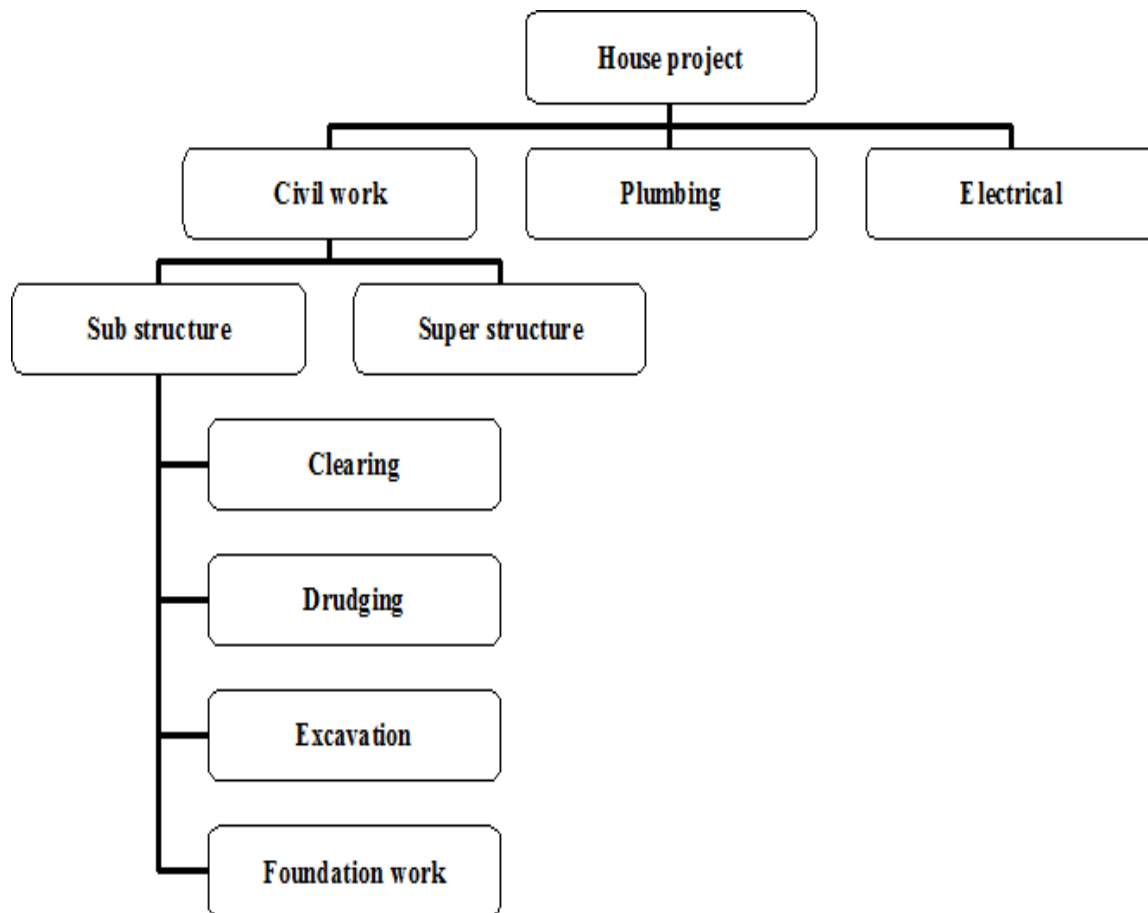
1.2.2 Sewerage

1.3.0 Electrical

1.3.1 Wiring

1.3.2 Appliances

b. Graphically



Showing the job activities and their order of sequence (logic) in pictorial form produces the project network. This network is being a graphical display of the proposed plan. With the information in the example, the next problem is to represent the activities in a network diagram and to determine all the precedence relationships among the activities. This representation is called an *activity-on-branch* diagram.

During its development, the Work Breakdown Structure (WBS) is related to the project organization by identifying the areas of the organization that will have functional and budgetary responsibility for each work package. Although relationships exist between all levels of the WBS and the project organization, the effective planning and control the accounts should be established at the lowest levels of the WBS- the work package level and possibly lower. Once work package responsibility has been assigned to a department, more detailed sub divisions can be made within the work

package by assigning responsibility down to still lower management and technical levels.

The interaction of the WBS and the organizational structure is represented by a chart called a **responsibility matrix** or **responsibility chart**. The responsibility matrix format is shown for one functional position and one work package. Every work package identified in the WBS should appear on the responsibility matrix. Each row in the responsibility matrix shows all of the person or functional positions involved in one work package and the type of involvement. Each column shows all the work tasks or work packages for which a single person or functional position is responsible.

An advantage of the matrix is that project personnel can easily see their responsibilities to work packages and to other individuals on the project. When further breakdown of assignments is necessary, those listed in the matrix can sub divide their respective tasks and make assignments to additional individuals.

The kind of responsibility defined for each organizational positions/ work packages intersection should be determined by mutual agreement of the workers assigned and their managers and other affected parties. This ensures consensus about the nature of responsibilities and enables everyone to share what they think is expected of them and what they expect from others.

To prevent confusion or conflict, the matrix can be filled in during a team building session using role analysis or similar techniques. Because the responsibility matrix prescribes how units in the organization should perform, it is useful for monitoring and assessing how well responsibilities are being performed. It permits managers and others to know where responsibilities lie and helps avoid 'passing the buck'. However, it obviously expresses only formal relationships and not necessarily how people really interact or other aspects of informal organization. Nonetheless, it is a useful planning device and helps reduce misunderstandings and conflict later on.

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Persons Responsible

Responsibility Code

P Primary responsibility
S Secondary responsibility
N Must be notified
A Must give approval

Project Task or Activity	Project Manager																												
	Project Engineer												Fabrication Manager																
	Design				Drawing				Software				Site Operations				Assembly A				Assembly B								
	F.W.	J.M.	S.E.H.	R.L.Q.	P.J.	D.V.R.	R.P.	O.E.M.	P.V.P.R.	D.M.N.	R.L.	L.S.F.	L.L.L.	J.R.S.	D.V.Q.	F.W.N.	J.M.M.N.	L.O.T.	A.U.A.	D.A.R.	B.O.B.	E.N.	G.G.F.	R.T.T.	B.V.L.	B.J.	T.T.Y.	H.R.D.	B.V.-Purchasing
Project coordination	P	S																		S									
Project development	A	P																											
Project design	A	P					A				N				A					N									N
H Basic design	N	A	A	P	S	S	N				N			N															
I Hardware design A			A	P	S																								
J Hardware design B			A	P	S						N																		
K Drawings B							A	S	P											N									
L Software specs		N	A								A	P	S	S															
M Parts purchase B		N																		A									P
N Parts purchase A		N																		A									P
O Drawings A						A		S	P											N									
P Installation drawings						A	P	S						N															
Q Software purchase		N																		A									P
U Assembly A		N																		N	A	P	S	S					
V Assembly B		N																		N					A	P	S		
W Test A		N													N					A	P								
X Test B		N													N					A						P			
Y Final installation		N													A	P	S	S											
Z Final test		N													A	P	S												

Fig: Responsibility Matrix Format