CIVL100 Introduction to Civil Engineering

CONSTRUCTION MANAGEMENT

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Outline of Presentation

• The Need for Project Management
  – Characteristics of construction industry
  – Construction Projects
• Organizations in Construction
• Project Delivery Process
• Construction Contracts and Contract Documents
• Estimating and Tendering
• Planning and Scheduling
• Quality Management
The Need for Project Management

- Construction industry
  - Long history
  - Fragmented - types of construction.
  - LARGE
  - DIVERSE
  - UNIQE
  - COMPLEX # players, defined roles and responsibilities, timing of participation, practice-sports, arts
  - Dynamic/continually changing
  - Non-repetitive
  - Lack of data
  - Lack of standardization
  - “Low tech”
  - Large number of participants
  - Legal and regulatory requirements
Civil Engineering Projects

Building Construction
Facilities commonly built for habitational, institutional, educational, light industrial (e.g. warehousing), commercial, social and recreational purposes.

Heavy Construction
Highway construction, sewage plants, utility projects, dams, pipelines, airports and waterways.

Industrial Construction
Manufacturing and production units. In some cases, specialty firms perform both design and construction under a single contract for the owner/client.
Civil Engineering Projects

SKYSCRAPERS
Civil Engineering Projects

AIRPORTS
Civil Engineering Projects

INDUSTRIAL BUILDINGS
Civil Engineering Projects

INDUSTRIAL BUILDINGS
A construction project consists of a series of tasks that have the following characteristics:

- Specific start and end dates;
- Defined scope and objectives;
- Budget and schedule;
- Unique and non-repetitive (particular mega projects);
- Consumes resources (e.g. money, materials, people (manpower), equipment (machines) and time (minutes).
Project Management

Project Management is the overall planning, control and coordination of a project from inception to completion aimed at meeting the client’s requirements and ensuring completion on time, within cost and to the required quality standards.
Project Management

Schedule

Project Management

Budget

Quality
Project Management

GOALS
- Planning
- Executing
- Controlling

PROJECT MANAGEMENT

END PRODUCT

Time
Fund
Equipment
Labor
Material
Organizations in Construction

Organizational contractual relationships can be classified into three groups:

• Traditional contractual organization

• Design and construction organization (TURNKEY)

• Professional Construction management
Organizations in Construction

PROFESSIONAL CONSTRUCTION MANAGEMENT

Client

Design and Cost Consultant

Management Contractor

Work Contractor

Subcontractor & Supplies
Organizations in Construction

ORGANIZATIONAL CHARTS

• Organizational Chart is a pictorial format showing all positions of:
  i) responsibility
  ii) all lines of supervision and authority
  iii) the lines of communication within the organization
• They are effective for quickly describing a company's structure.
• Chart is useful for employees. Shows their position in the company, identifies their supervisor, those whom they supervise, and the nature of their duties.
• The two predominant aspects of most organization charts are those depicting vertical and horizontal specialization.
  • Vertical specialization refers to the hierarchical structure of authority.
  • Horizontal specialization is the differentiation of functions within a level of the hierarchy.
Organizations in Construction

MATRIX ORGANIZATION STRUCTURE
Organizations in Construction

TEAM ORGANIZATION

- Project Manager
- Steering Committee
- Assistants of Project manager
Organizations in Construction

TEAM ORGANIZATION

• Contractor site key personnel are:
  – the agent
  – site engineer
  – Office manager
  – general foreman
  – plant manager (foreman)
Project Delivery Systems

- Project delivery methods
  - Design-Bid-Build
  - Phased Construction
  - Design-Bid-Build-Warranty
  - Design-Build
  - Engineer-Procure-Construct
  - Indefinite Delivery/Indefinite Quantity
Project Delivery Systems

• Commercial contract terms
  – Lump Sum
  – Cost-Plus-Fee
  – Unit Price
  – Alternate Methods for Contract Award
  – A+B (Time + Cost, Multiparameter)
  – Best Value (Price + Quality)
  – Bid Averaging Method
  – Optionally Combined Bidding
Ability to Influence Cost

Planning: 5-15%
Design: 2-20%
Construction: 65-93%
Startup & Commissioning: 0.5-5% Capital Investment
Operation & Maintenance: Low

Time
Parties to a Project

- Contractor’s Insurance
- Suppliers
- Architects
- Engineers
- Consultants
- Attorneys
- Accountants
- Unions
- Specialty Contractors
- Designer Insurance
- Owner’s Insurance
- Owner
- Permanent Lender
- Interim Lender
- National Government
- Regional Government
- Local Government
- Project Management
- General Contractor
- Vendors
Facility Delivery Process

Market Demands or Perceived Needs → Conceptual Planning & Feasibility Studies → Design & Engineering → Procurement & Construction

Startup for Occupancy → Operation & Maintenance → Renovation Conversion or Demolition

*“Project Management for Construction”; Chris Hendrickson & Tung Au
Prentice Hall; 1989
“Let me see those blueprints again”
Facility Delivery Process

• Planning
  – owner expresses a need for a new facility
  – concepts are worked out
  – feasibility studies are a must

• Design
  – Where the majority of engineering takes place
  – Detailed plans and specifications are developed
  – Owner’s initial ideas are further refined
  – Owner gives go-ahead
  – Contract is bid and awarded
Facility Delivery Process
Facility Delivery Process

There Comes A Time in The History Of Every Project When It Becomes Necessary to Shoot the Architects and Begin Production
Facility Delivery Process

Do you mean you want the revised revision of the original revised revision revised?
Facility Delivery Process

- **Construction**
  - Where the physical manifestation of the design appears
  - Design often continues through construction

- **Startup and Commissioning**
  - Verifying whether the constructed facility operates as designed

- **Operation and Maintenance**
  - Owner accepts built facility
  - Facility continues in O&M until it is renovated or decommissioned
Documents of Contract

A construction contract comprises:

a) **Contract drawings:** Pictorially shows the works, dimensions & levels.

b) **Specifications:** work is described in **Words**. The quality of materials, workmanship, and testing methods.

c) **Bill of quantities:** gives the expected measure of each operation from the drawings. Operations are classified according to trade or location within the work.

d) **General Conditions of Contract:** defines the liabilities, responsibilities, and power of employer, engineer & contractor. Methods of payment, insurance also mentioned.

e) **Tender:** Signed financial offer of the contractor to construct the work.

f) **Letters of Explanation:** Covers agreed matters between the parties to elucidate their intentions.

g) **Legal Agreements:** Signed by both parties, owner & contractor, confirming their intentions.
Forms of Construction Contracts

Terms of Contract

- definition of work, estimated cost, & the fee of contractor
- time for completion
- responsibilities of owner, engineer & contractor
- definition of reimbursable direct cost & overhead costs
- labour & material
- provisions for plant rental or purchase
- subcontractors
- method of compensation
- Changes
- Termination
- Accounting method and control
Specifications

• While the drawings show the extent of the quantity of works, specifications define the quality and standard of it.
• Specifications are prepared by engineers, and contracts are prepared by lawyers.
• Specifications are supposed to be specific- not general.
• In specification, the following characteristics should be covered.
Bill of Quantities

- Bill of Quantities is a contract document to define the quantity of work to be done in each type of activity of the contract.
- Quantities are exact, measured from drawings.
- When the work is constructed, the quantities are replaced by the measurement of the actual quantity of the work.
Costing

- Precise costing is almost impossible.
- Cost is just predicted.
- Costing is defined as, finding the cost of separate classes of work, such as bricklaying, shuttering etc.
- Costing involves finding charges for
  - Labour
  - Material
  - Plant and
  - Overhead
Cost Estimating Processes

Basic steps of estimating are:

a) Decision to tender
b) Programming the estimate
c) Collection and calculation of cost information.
d) Project study
e) Preparing the estimate
f) Site overheads
g) Estimator's report
Calling for Tender

There are three commonly practiced tendering procedures:

- Open tendering (advertising to anyone interested)
- Selecting tendering (Pre-qualified Tendering) (approaching several potential contractors)
- Negotiating tendering (approaching the preferred contractor).
Choosing a Tender

- Having completed close check and comparison, the engineer invites one or two of the lowest tenderers to his office.
- Engineer investigates further about contractors to see the proposed method of construction, proposed program.
- Contact with referees of contractors.
- The decision is made to recommend a contractor to the client.
- Meanwhile, the engineer will not reveal to any contractor the prices of other contractors.
Documents that a Bidder Should Submit

1. Registration
2. Bonds
3. Contractorship license
4. Permission to take part in biddings
5. Documents showing that company is active
6. Signature
Planning & Scheduling a project is an administrative process. The objectives of planning & scheduling are:

- To forecast the resource requirements of people, material and equipment.
- To forecast the financial requirements.
- To provide a suitable control tool against which progress can be measured.
- To minimize the unproductive time of both men and machine.
- To find the time required completing the project.
- To establish the time for delivering the materials required.
Project Planning & Scheduling Techniques

The most common and widely used Project planning & scheduling techniques are:

- Bar charts and linked bar charts.
- Network analysis, either activity on the arrow or on the node.
- Line of balance, for repetitive construction work.
### Project Planning & Scheduling Techniques

![Linked bar chart (Gantt Chart)](image)

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A. Organize</td>
<td>1 day</td>
</tr>
<tr>
<td>2</td>
<td>B. Site layout</td>
<td>1 day</td>
</tr>
<tr>
<td>3</td>
<td>C. Excavation</td>
<td>2 days</td>
</tr>
<tr>
<td>4</td>
<td>D. Foundation</td>
<td>4 days</td>
</tr>
<tr>
<td>5</td>
<td>E. Floor slab</td>
<td>1 day</td>
</tr>
<tr>
<td>6</td>
<td>F. Structures</td>
<td>6 days</td>
</tr>
<tr>
<td>7</td>
<td>G. Roof construction</td>
<td>2 days</td>
</tr>
<tr>
<td>8</td>
<td>H. Brick work</td>
<td>4 days</td>
</tr>
<tr>
<td>9</td>
<td>I. Masonry</td>
<td>1 day</td>
</tr>
<tr>
<td>10</td>
<td>J. Plumbing &amp; elec. work</td>
<td>2 days</td>
</tr>
<tr>
<td>11</td>
<td>K. Plastering</td>
<td>4 days</td>
</tr>
<tr>
<td>12</td>
<td>L. Door and windows</td>
<td>1 day</td>
</tr>
<tr>
<td>13</td>
<td>M. Roof covering</td>
<td>1 day</td>
</tr>
<tr>
<td>14</td>
<td>N. Painting</td>
<td>2 days</td>
</tr>
<tr>
<td>15</td>
<td>O. Glazing</td>
<td>1 day</td>
</tr>
<tr>
<td>16</td>
<td>P. Clearing</td>
<td>1 day</td>
</tr>
<tr>
<td>Item</td>
<td>Activity Description</td>
<td></td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>A1</td>
<td>Excavation</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>Sand under Footing</td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>Compact Soil</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>Hardcore</td>
<td></td>
</tr>
<tr>
<td>B11</td>
<td>Plain concrete for footings</td>
<td></td>
</tr>
<tr>
<td>B12</td>
<td>Plain concrete for slabs on grade</td>
<td></td>
</tr>
<tr>
<td>B13</td>
<td>Plain concrete for roof grading</td>
<td></td>
</tr>
<tr>
<td>B21</td>
<td>Reinforced concrete for footings</td>
<td></td>
</tr>
<tr>
<td>B22</td>
<td>Reinforced concrete for ground beams</td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>Reinforcement For Footing</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Reinforcement For Columns</td>
<td></td>
</tr>
</tbody>
</table>
Activity Duration Estimation

If the work is expressed in terms of quantity (m2 of formwork, ton of steel, m3 of concrete etc) then activity duration is estimated as:

\[ D_{ij} = \frac{Q_{ij}}{P_{ij} \times N_{ij}} \]

- \( D_{ij} \) = Duration of activity in units of time
- \( Q_{ij} \) = Quantity (m2, m3, ton, pieces etc)
- \( P_{ij} \) = Average productivity of standard crew
- \( N_{ij} \) = Number of standard crew assigned to activity
### Relationship Types

<table>
<thead>
<tr>
<th>Link type</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finish-to-start (FS)</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td>The dependent task (B) cannot begin until the task that it depends (A) on is complete. For example, if you have two tasks, &quot;Dig foundation&quot; and &quot;Pour concrete,&quot; the &quot;Pour concrete&quot; task cannot begin until the &quot;Dig foundation&quot; task is complete.</td>
</tr>
<tr>
<td>Start-to-start (SS)</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td>The dependent task (B) cannot begin until the task that it depends (A) on begins. The dependent task can begin anytime after the task that it depends on begins. The SS link type does not require that both tasks begin simultaneously. For example, if you have two tasks, &quot;Pour concrete&quot; and &quot;Level concrete,&quot; the &quot;Level concrete&quot; task cannot begin until the &quot;Pour concrete&quot; task begins.</td>
</tr>
<tr>
<td>Finish-to-finish (FF)</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td>The dependent task (B) cannot be completed until the task that it depends on (A) is completed. The dependent task can be completed anytime after the task that it depends on is completed. The FF link type does not require that both tasks be completed simultaneously. For example, if you have two tasks, &quot;Add wiring&quot; and &quot;Inspect electrical,&quot; the &quot;Inspect electrical&quot; task cannot be completed until the &quot;Add wiring&quot; task is completed.</td>
</tr>
<tr>
<td>Start-to-finish (SF)</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td>The dependent task (B) cannot be completed until the task that it depends on (A) begins. The dependent task can be completed anytime after the task that it depends on begins. The SF link type does not require that the dependent task be completed concurrent with the beginning of the task on which it depends. For example, the roof trusses for your construction project are built offsite. Two of the tasks in your project are &quot;Truss delivery&quot; and &quot;Assemble roof.&quot; The &quot;Assemble roof&quot; task cannot be completed until the &quot;Truss delivery&quot; task begins.</td>
</tr>
</tbody>
</table>
Quality Management

Quality Control/Quality Assurance

Owner's Needs → Design Criteria → Design Process → Technical Specifications

Construction Methods

Supervision and Control

Inspection → Conformance to Specs

Quality of Constructed Facility
Quality Management

Quality Control includes:

- setting specific standards for construction performance, usually through plans and specs
- measuring variances from the standards
- taking action to correct or minimize adverse variances
- planning for improvements in the standards

The architects and design engineers set the criteria for construction, QC ensures that the physical work conforms to those standards