FE REVIEW COURSE – SPRING 2017
Construction

4/19/2017
Construction Knowledge

• 4 – 6 problems
  ▪ Construction documents
  ▪ Procurement methods
  ▪ Project delivery methods
  ▪ Construction operations and methods
  ▪ Project scheduling
  ▪ Project management
  ▪ Construction safety
  ▪ Construction estimating

• Sections in *FE Reference Handbook*
  ▪ Civil Engineering
  ▪ Industrial & Systems Engineering

Exam specifications around the topic of Construction

Sections in *FE Reference Handbook*
Overview and flow of Chapter 53
Project Management

- Coordination of the entire process of completing a job, from its inception to final move-in and post-occupancy follow-up.
  - Process-based
  - Each process occurs within one of the five process groups

The Project Management Institute has developed the primary resource used in this field
- “*A Guide to the Project Management Body of Knowledge (PMBOK Guide)*”
  - Process-based = describes projects as being the outcome of multiple processes.
  - Each process occurs within one of the five process groups (SEE GRAPHIC)
  - Identifies 9 PM knowledge areas typical of nearly all projects.
    - Integration, Scope, Time, Cost, Quality, Human Resources, Communications, Risk, and Procurement.
  - Matrix: Every process is related to one knowledge area and one process group.
  - Time and Cost are often most important.
Cost estimating consists of compiling and analyzing all factors that can influence costs.

Estimators must develop a thorough understanding of the project and deliverables, and resources required.

Involves determining the quantity of materials and labor the firm will need to furnish – called a “takeoff”.

- Can be done manually, but numerous solutions are available with current software/technologies.

Estimators for general contractors often have the responsibility of analyzing bids made by subcontractors.

The takeoff process requires consideration or judgment concerning equipment needs, the sequence of operations, the size of the crew required, and physical conditions at the project site. Allowances for waste, inclement weather, shipping delays, etc. must also be considered.

Estimators may be hired by the project owner to estimate project costs or to track actual expenses. They can even specialize in specific scopes of work.
2 primary elements that affect a project’s schedule

1. Design Sequencing
   • In which the engineer/architect has control

2. Construction Sequencing
   • Contractor has control

Prior to design process beginning, information must be gathered about the owners goals and objectives, as well as additional factors influencing design. This is known as *programming*. After this, the design process may begin.

The design process normally consists of several clearly defined phases. Each being completed/approved before proceeding to the next. AIA commonly refers to the phases as:

- **Schematic Design, Design Development, Construction Documents, Bidding or Negotiation, & Construction** phases.
- Time of each varies widely depending on different factors. (E.g., size, complexity, resources, owner decision/approval processes.)

The construction schedule can be determined by the contractor, construction manager, or designer.

Many variables affect construction time. Beyond size and complexity, weather, material/labor availability, and party responsiveness are just a few.
For the sake of reducing on-site erosion and off-site sedimentation that might affect water resources, *construction sequencing* is an important concept that seeks to balance timing/sequencing of land disturbance activities with the installation of ESC/EPSC measures.
Time and costs of a project are intricately related. Thus a time-cost trade-off is ever-present. Cost increases as the project time decreases and vice versa.

Total time is determined by critical path. This becomes the focus of compression or “crashing”. The optimal time can be found by determining the normal completion time and costs for each critical path activity, then comparing it to the it’s respective “crash” time.
Construction time can be compressed with fast-track scheduling.

- Overlaps the design and construction phases of a project.
- Typically results in 10-30% less time.
Schedule Management

The most common and easiest method is the bar chart or Gantt Chart.

- Activities along vertical axis, each with start and finish dates
- Suitable for small to midsize projects
- Doesn’t show all sequences or dependencies.

Critical path techniques are used to graphically represent the multiple precedence relationships in a complicated project.

- Used to control and monitor the progress, cost, and resources of a project.
- Techniques use directed graphs made up of arcs (arrows) and nodes (junctions)
- Durations and precedences shown in precedence table (matrix).
**Resource Leveling** is used to address *overallocation*.

- Typically people and equipment are limiting factors, funding can be also.

Two common ways:
1. Tasks can be delayed until resources become available.
2. Tasks can be split so that the parts are completed when planned and remaining work is completed when resources become available.

Leveling applied to critical path will inevitably extend the completion date.
Critical path method (CPM) is one of several techniques that uses a directed graph.

- requires that all activity durations be specified by single values
  - It’s a deterministic method
  - Each activity (task) is represented by a node (junction)
  - Each activity is connected by arcs (connecting arrows, lines, etc.)
    - Arcs have zero (0) duration

Dummy nodes or milestones may be used to specify the start and/or finish of the project.

A CPM graph depicts the activities required to complete a project & the sequence in which the activities must be completed.

No activity can begin until all of the activities with arcs leading into it have been completed.
Solving a CPM Problem with an Activity-on-Node Network

1. Place the project start time or date in the ES and EF positions of start activity. The start time is 0 for relative calculations.

2. Consider any unmarked activity, all of whose predecessors have been marked in the EF and ES positions. (Go to #4 if none.) Mark in its ES position the largest number marked in the EF position of those predecessors.

3. Add the activity time to the ES time and write this in the EF box. Go to #2.

4. Place the value of the latest finish date in the LS and LF boxes of the finish mode.

5. Consider unmarked predecessors whose successors have all been marked. Their LF is the smallest LS of the successors. Go to #7 if there are no unmarked predecessors.

6. The LS for the new mode is LF minus its activity time. Go to #5.

7. The float for each node is LS-ES and LF-EF.

8. The critical path encompasses nodes for which the float equals LS-ES from the start node. There may be more than one critical path.
Activity-on-Arrow Networks

- Duration of a project = the sum of all durations of activities on the critical path
- Activity duration is notated by activity-on-arrow network

ACTIVITY-ON-ARROW ANNOTATION

EARLY START/LATE START  EARLY FINISH/LATE FINISH

\[\text{ACTIVITY DURATION}\]

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Activity-on-Arrow Networks Example

An activity-on-arrow diagram for a project is

If the critical path is B-E-G-J-K, what is most nearly the duration of the project?

(A) 20 days
(B) 21 days
(C) 26 days
(D) 27 days
Deterministic models have explicit durations...

In Stochastic models, time is distributed as a random variable.

**Most common model is PERT**

- Stands for Program Evaluation and Review Technique
- Used for large projects

**Stochastic Critical Path Models**

- Time is distributed as a random variable
- Most common model is PERT
  - Program Evaluation and Review Technique
  - Used for large projects

PERT

\( (a_{ij}, b_{ij}, c_{ij}) \) = (optimistic, most likely, pessimistic) durations for activity \((i, j)\)

- \(\mu_{ij}\) = mean duration of activity \((i, j)\)
- \(\sigma_{ij}\) = standard deviation of the duration of activity \((i, j)\)

- \(\mu\) = project mean duration
- \(\sigma\) = standard deviation of project duration

\[
\begin{align*}
\mu_{ij} &= \frac{a_{ij} + 4b_{ij} + c_{ij}}{6} \\
\sigma_{ij} &= \frac{c_{ij} - a_{ij}}{6} \\
\mu &= \sum_{(i, j) \in CP} \mu_{ij} \\
\sigma^2 &= \sum_{(i, j) \in CP} \sigma_{ij}^2
\end{align*}
\]
• \( \mu_{ij} \) is the mean duration
• \( \Sigma_{ij} \) is the standard deviation of the duration of activity
• \( \mu \) is project mean duration
• \( \sigma \) is the standard deviation of project duration

• \( a_{ij} \) is the most optimistic duration of activity \( (i, j) \),
• \( b_{ij} \) is the most likely duration of activity \( (i, j) \), and
• \( c_{ij} \) is the most pessimistic duration of activity \( (i, j) \)
Stochastic Critical Path Models Example

Durations for a project’s four key activities are shown.

<table>
<thead>
<tr>
<th>activity</th>
<th>optimistic</th>
<th>most likely</th>
<th>pessimistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>5</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>1-3</td>
<td>5</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>2-4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>3-4</td>
<td>1</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

What is most nearly the mean duration of activity 1-2?

(A) 3.5 hr
(B) 4.0 hr
(C) 6.2 hr
(D) 7.1 hr
Monitoring is keeping track of the progress of the job to see if the planned aspects of time, fee, and quality are being accomplished.

Original fee projections can be monitored
• Comparing weekly timesheets with the original estimate.

Example shows per phase as well as cumulative progress.

Monitoring quality is more difficult. The status of meeting goals and expectations should be checked regularly. Should also review work regularly to ensure it is technically correct and that all contractual obligations are being met.
Coordinating

Project Managers must constantly coordinate the various stakeholders:

- Architect/engineer’s staff
- The consultants
- The clients
- Building code or regulatory officials
- Internal management
- Contractors

Checklists or meetings can be valuable for coordinating.
Earned Value Method

There are three primary measures of project performance: BCWS, ACWP, and BCWP.

- Budgeted cost of work scheduled (BCWS)
- Actual cost of work performed (ACWP)
- Budgeted cost of work performed (BCWP)

Secondary Measures:

Variances
- Cost variance (CV) is the difference between the planned and actual costs of the work completed
- Schedule variance (SV) is the difference between the value of work accomplished for a given period and the value of the work planned

Indices
- Cost performance index (CPI) is a cost efficiency factor representing the relationship between the actual cost expended and the earned value.
- Schedule performance index (SPI) is a measure of schedule effectiveness, determined from the earned value and the initial planned schedule.

Forecasting
- Estimate to complete (ETC) is a calculated value representing the cost of work required to complete remaining project tasks
- Estimate at completion (EAC) is a calculated value that represents the projected total
Chapter 54

Procurement & Project Delivery Methods

Introduction

Design-Bid-Build

Awarding Contracts

Design-Build

Management Contracting

25
The procurement stage is when a project manager
- plans purchases, acquisitions, and contracts;
- requests supplier and contractor responses;
- selects suppliers and contractors;
- and awards, administers, and closes contracts.

3 types of contract structure may be used to deliver the project:
- design-bid-build,
- design-build, and
- management contracting.

Each contract type involves the same parties:
- the design professional,
- the owner, and
- the contractor (responsible for coordinating the work of any subcontractors, fabricators, and suppliers).
**Design-Bid-Build**

The traditional approach to project delivery.

- Generally produces the lowest cost
- Construction documentation must be completely finished before bidding (all things equal except price).

Multiple-prime project delivery

- Owner or a contracted construction manager creates a bid package for each subdivision of work (e.g., heating, ventilating, and air conditioning (HV AC); framing; plumbing; electrical).
- Lowest bidder for each work subdivision is awarded the respective contract.
- Less appropriate for extremely complex projects.
Design-Build

Places responsibility for both design and construction on one entity.

The lead professional may be:
- An engineer paired with a construction company.
- Construction company paired with engineers/architects.

Design and construction personnel work together without the usual adversarial roles.

The same entity is pricing all work, so a fixed, guaranteed price can be offered.
Management Contracting

Construction Manager (CM) – a third party who is an expert in the construction, costing, and management of the construction process.

- May be hired to advise on costs and construction methods, but not participate in construction.
- May act as an agent; responsible for hiring contractors, advising on costs, and managing the construction process.
- Can act as contractor, guaranteeing the price of the project.

Traditional D-B-B method can be used, with CM consulting early on with costs/constructability details.

Commonly, CM will act as agent of the owner:
- Advising the engineer on material selection, costs, and constructability;
- Selecting contractors and subcontractors;
- Negotiating their contracts and construction pricing; and
- Coordinating construction.

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- Negotiating their contracts and construction pricing; and
- Coordinating construction.
Contracts can be awarded either through negotiation or competitive bidding.

**Negotiation**
- The owner, with the assistance of the construction manager or engineer, works out the final contract price and conditions with each contractor.

**Competitive Bidding**
- Lowest responsible bidder
  - Lowest bidder whose offer best responds in quality, fitness, and capacity to fulfill the particular requirements of the proposed project, and who can fulfill these requirements with the qualifications needed to complete the job in accordance with the terms of the contract.
  - Not prohibited, but uncommon for engineering services.
Awarding Contracts Example

Ethical codes and state legislation forbidding competitive bidding by design engineers are:

(A) enforceable in some states
(B) not enforceable on public (nonfederal) projects
(C) enforceable for projects costing less than $5 million
(D) not enforceable
Chapter 55

Construction Documents

- Introduction
- Specifications
- Documentation
- Construction Plans
Construction plans, specifications, and any necessary contracts or supporting documents must be produced at the start of a project. Collectively, these documents are known as the **Construction Documents**.

Must be of sufficient clarity to indicate...
- Location, nature, and extent of proposed work;
- And how it will conform to code/specifications.

Includes:
- Standard drawings, elevations/profiles, sections, and details, item/material schedules, and specifications
Documentation

- Change orders (i.e. record drawings)
  - Due to unexpected conditions or changes to the plans after bidding
- As-built construction documents
  - Record what was actually installed (as opposed to what was shown in the original construction documents)

Documentation is critical!!! Provides
• a record in legal disputes
• Project history
• Accurate & clear form of communication

Particularly important documents include:
Change orders (a.k.a., record drawings)
  - Due to unexpected conditions or changes to the plans after bidding
As-built construction documents
  - Record what was actually installed (as opposed to what was shown in the original construction documents)
Documentation Example

Record **drawings** ("as-buils") of a buried sewer line installation that will be submitted to the client should be certified by the

(A) contractor
(B) building official
(C) architect
(D) engineer
Construction Plans

Also called plan views, floor plans, and partition plans.

- Required for every project regardless of size or complexity
- Drawn at different scales depending on project
  - 1/8 in = 1 ft 0 in (1 :100)
  - 1/4 in = 1 ft 0 in (1: 50)
  - 1/2 in = 1 ft 0 in (1:25)
- All plans should be drawn at the same scale as the primary construction plan.
Specifications

- Dictate which materials and methods must be used
- Separate from the plans and drawings
- Become part of the construction contract
- Assembles and consolidates all of the specific and technical details that apply to a project

Often possible to adopt commercial documents that use standard information, language and content.
  - E.g., The Construction Specifications Institute (CSI) MasterFormat™ document
Chapter 54
Equipment Productivity & Selection

- A major influence on the efficiency and profitability of a construction operation.
- Most important considerations are the equipment’s ability to perform the work, its efficiency, and its cost.
- Evaluated by the cost per unit of production (CPP).
- Basic method for calculating production capability is based on the equipment’s capacity and cycle time.
  - 2 ways to estimate cycle time
    1. Number of effective working minutes per hour
    2. Multiply the theoretical number of cycles per hour by a numerical efficiency
- Common categories:
  - Excavation and loading equipment
  - Hauling and placing equipment
  - Compaction equipment
  - Grading and Finishing equipment

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Cranes

- Engineer’s must understand:
  - How to select the right crane for the right activity,
  - How to properly erect a crane and
  - How to keep it stable.
- Crane evaluation includes determining:
  - Type and size of crane needed,
  - Load capacity required, and
  - Other specifications as required for the project.
- Crane Types
  - Rough terrain
  - Truck mounted
  - All terrain- road worthy blend of rough terrain and truck mounted
  - Crawler lattice – high capacity, long-reach
  - Tower – small footprint, moving counterweight
- Load capacity for a crane is never more than 75% of its tipping load.

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Load capacity for a crane is never more than 75% of its tipping load.
Load capacities for a crane are provided on the crane's load chart.
Along with a load chart and data sheet, the manufacturer will usually provide a working range diagram
• left axis of the diagram shows the boom lengths available for the crane, and
• the right axis shows the distance from the ground to the elevation where the load will be set
In some situations, a crane's specifications and diagrams don't provide enough info to make a decision. The positioning of a crane can have a major effect on its load capacity and tipping load, and there are projects for which the exact tipping load of the crane must be known. In these instances, the construction engineer must determine the static basis for the crane.
Rigging

- Slings, spreader beams, lifting brackets, and pincers are different methods to attach a load to the hook block of a crane.
- Slings are most commonly used.
- Beams are usually lifted using a choker at the center of gravity.
- A beam may also be hoisted with two cables.

Figure 56.8 Lifting a Single Beam

tension force equal to $W$

Page 56-9
• A spreader beam is used to attach the multiple loads to the rigging.
• OSHA Subpart R has specific requirements for multiple lift rigging.
• In all cases, the first step is to determine the center of gravity of the combined load.
• The lifting point is always directly above the center of gravity.
Productivity Analysis & Improvement

- Understanding productivity requires optimizing both
  - The production capability of the equipment used on the project, and
  - The production capability of the crew working on the project.
- Requires careful observation and sound judgment using established methods
- Productivity analysis categories:
  - Productive work
  - Contributory work
  - Nonproductive work
  - Obstructive work
- Most basic method is to observe the percentage of time a crew performs effective work.
- Better method is the calculation of a labor utilization factor.

Understanding productivity requires optimizing both
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Productivity analysis categorizes work as:

- **Productive work** - work that contributes directly to the completion of the activity
- **Contributory work** - work that does not contribute directly to activity completion, but is either essential for completion or increases the efficiency of the direct work.
- **Nonproductive work** - does not contribute to completion or efficiency, or work that has already been done and must be redone due to errors or delays.
- **Obstructive work** - prevents the activity from being completed

Most basic method is to observe the percentage of time a crew performs effective work. Better method is the calculation of a labor utilization factor.

- random observations of various project crews or pieces of equipment performing the same activity.
- Typically 25% to 50%, depending on the activity.
Learning Curves

- A mathematical representation of time spent to produce a unit of work.
- By integrating the area under the curve, an estimator can calculate the total hours of labor needed to complete an activity.
Site Dewatering & Pumping

- **Dewatering (unwatering)**
  - The removal of water from the job site, typically requiring a lowering of the water table.
  - Costs are primarily a function of the volume of water removed.
- **Deep wells**
  - Use submersible electric pumps to lower the water table.
- **Vacuum dewatering**
  - Uses wellpoints to draw water up small-diameter (e.g., 2 in) tubes with side perforations in the liquid water zone.
  - Typical when depth is less than about 15-20 ft.
  - Wellpoints are usually installed around the project's periphery.
  - Sites can be dewatered to depths greater than 15-20 ft by using multiple wellpoint stages.

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Site Dewatering & Pumping

Example Vacuum dewatering operation.
Chapter 57
Introduction

• In the U.S., workers' safety is regulated by the federal Occupational Safety and Health Act (OSHA)
  • State divisions are charged with enforcing federal and state safety regulations
• Surface and underground mines are regulated by the federal Mine Safety and Health Act (MSHA).
• All federal OSHA regulations are published in the Congressional Federal Register (CFR).
  • 2 main categories
    – The "1910 standards" for general industry
    – The "1926 standards," for construction industry
    – Subjects include: Fall protection, trenching, scaffolds, and confined space entry to name a few.

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Soil Classification

Soils are classified into stable rock and types A, B, or C, with type C being the most unstable.

- Where a layered geologic structure exists, the soil must be classified on the basis of the soil classification of the weakest soil layer.
- OSHA requires that at least one visual and one manual method be used to classify the soil type as A, B, and C.

Type A soils are cohesive soils with an unconfined compressive strength of 1.5 tons per square foot or greater. Examples of type A cohesive soils are clay, silty clay, sandy clay, clay loam. No soil is type A if it is fissured.

Type B soils are cohesive soils with an unconfined compressive strength greater than 0.5 tons per square foot but less than 1.5. Examples of type B soils are angular gravel; silt; silt loam.

Type C soils are cohesive soils with an unconfined compressive strength of 0.5 tons per square foot or less. Type C soils include granular soils such as gravel, sand and loamy sand, submerged soil, soil from which water is freely seeping, and submerged rock that is not stable.
• Except for excavations entirely in stable rock, excavations >5’ in all types of earth must be protected from cave-in and collapse [OSHA 1926.652].
• <5’ deep may need to be protected when hazardous ground movement is possible.
• Shoring and trench shields that meet OSHA requirements may be used up to 20’ deep.
• Sloping and benching trench walls may be substituted for shoring.
  • Sloped walls in excavations deeper than 20 ft must be designed by a professional engineer.
  • Table 57.2 provides maximum slopes for excavations less than 20 ft deep. Type A soils options are shown.
  • Greater slopes are permitted for short term usage in excavations less than 12ft deep.
Competent Person: Soil Excavating

Example
The first person to enter an excavation should normally be a

(A) competent person
(B) trained person
(C) newly hired person
(D) supervisor
• OSHA requires the dangers of all chemicals be known to employees.
• Hazards are communicated in a variety of ways, including labeling containers, training employees, and providing ready access to material safety data sheets (MSDSs).
• The information contained on an MSDS consists of the chemical identity and 9 information sections.
• OSHA Pictograms
Confined Spaces & Hazardous Atmospheres

• Employees entering confined spaces (e.g., excavations, sewers, tanks) must be properly trained, supervised, and equipped.
• Atmospheres in confined spaces must be monitored for oxygen content and other harmful contaminants.
• Oxygen content must be maintained at 19.5% or higher unless a breathing apparatus is provided [OSHA 1910.146].
• Employees entering deep confined excavations must wear harnesses with lifelines [OSHA 1926.651].

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Power Line Hazards

- Critically important to be aware of the possibility of inadvertent power line contact.
- Site must be thoroughly inspected for the danger of power line contact.
- OSHA provides specific minimum requirements for safe operating distances.
- A good rule of thumb for voltages >50 kV is a clearance of 35ft.
Fall & Impact Protection

• Fall protection can take the form of barricades, walkways, bridges (with guardrails), nets, and fall arrest systems.
• Personal fall arrest systems include lifelines, lanyards, and deceleration devices.
• Employees must be protected from impalement hazards from exposed rebar [OSHA 1926.701 (b)].
• Head protection is required where there is a danger of head injurie from impact, flying or falling
• Object, electrical shock, or burns. [OSHA 1910.132(a) and (c)].

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Noise

- OSHA sets maximum limits on daily sound exposure.
- The "all-day" eight-hour noise level limit is 90 dBA.
- In the U.S., employees may not be exposed to steady sound levels above 115 dBA, regardless of the duration.
- Impact sound levels are limited to 140 dBA.
- Permissible Noise Exposure Levels shown on Table 57.4.

<table>
<thead>
<tr>
<th>sound level (dBA)</th>
<th>exposure (hr/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>8</td>
</tr>
<tr>
<td>92</td>
<td>6</td>
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<td>95</td>
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<td>105</td>
<td>1</td>
</tr>
<tr>
<td>110</td>
<td>1/2</td>
</tr>
<tr>
<td>115</td>
<td>1/4 or less</td>
</tr>
</tbody>
</table>
Scaffolds

- Construction and use of scaffolds are regulated in detail by OSHA Std. 1926.451.
- Fall protection required on a scaffold more than 10’ above a lower level.
- Planking or decking cannot deflect more than 1/60 of the span when loaded.
- Each platform and walkway must be at least 18 in wide.

• Scaffolds are any temporary elevated platform (supported or suspended) and its supporting structure (including points of anchorage) used for supporting employees, materials, or both.
• Construction and use of scaffolds are regulated in detail by OSHA (Std. 1926.451).
• Fall protection required on a scaffold more than 10 ft above a lower level.
• Planking or decking cannot deflect more than 1/60 of the span when loaded.
• Each platform and walkway must be at least 18 in wide.
**Temporary Structures**

- Temporary structures are those that exist for only a period of time during construction and are removed prior to project completion.
- They include:
  - temporary buildings for occupancy and storage,
  - shoring and underpinning,
  - concrete formwork and slipforms,
  - scaffolding
  - diaphragm and slurry walls,
  - Wharves and docks,
  - temporary fuel and water tanks,
  - cofferdams, earth-retaining structures,
  - bridge falsework, tunneling
  - supports, roadway decking, and ramps and inclines.
Truck & Tower Cranes

- Crane capacities also depend on the *reeving*,
  - the path of the wire rope as it comes off the hoist drum and wraps around the various upper and lower sheaves.
- When the hoist line is not centered over the boom tip, *eccentric reeving* occurs

**Question**
What is the danger of eccentric boom reeving?
(A) boom twisting
(B) decreased jib capacity
(C) increased wire rope wear
(D) increased sheave wear

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What is the danger of eccentric boom reeving?
- A. This causes torque (twisting) in the boom.
Crane Use & Safety

- OSHA federal crane safety regulation; for general industry are covered in 3 section of the CFR (29 CFR Sections 1910.179, 1910.180 and 1917.45).
- OSHA (Section 29 CFR 1926.1412) makes a distinction between competent and qualified persons.
- Only a qualified person can conduct annual inspections of equipment; inspections of modified, repaired, and adjusted equipment; and inspections after equipment has been assembled.
- A competent person may conduct the work shift and monthly equipment inspections, as long as that person has been trained in the required elements of a shift inspection.
- The crane or derrick operator can be the inspector, but only if the operator meets the respective requirements for a qualified or competent person.