



مدیریت پروژه‌های صنعت ساخت (ساختمانی، زیرساختی و صنعتی)

فصل سوم: قراردادهای ساخت
ساختار کلی مناقصات
ساختار قراردادی و تفصیلی مناقصات

ارائه دهنده:

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(PhD, PMP, CMIT)

دانشگاه Illinois Tech آمریکا

What we will learn?

- ☐ How we get the work?
- ☐ Construction contracts
- ☐ Organization of contract documents
- ☐ Contract pricing methods
- ☐ Standard contract forms
- ☐ Bonds
- ☐ Insurance
- ☐ Procurement methods
- ☐ Making the bid/no bid decision
- ☐ Subcontracting

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STANDARD CONTRACT FORMS

Standard contract forms

- ☐ Contracts are either standard or specially prepared agreements.
- ☐ **Most government agencies** use standard formats for developing **construction contract documents**.
- ☐ Federal and state agencies typically have **standardized** general conditions and agreement language that is **prescribed by government** procurement regulations.

Standard contract forms

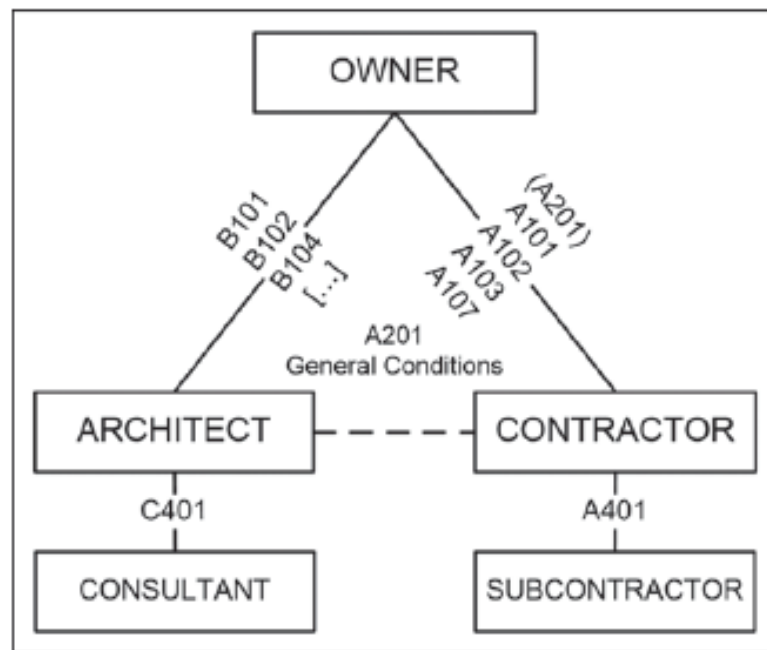
❑ Many **local government agencies** and **private owners** use contract formats developed the **following professional organizations**:

- ❖ ConsensusDocs (www.ConsensusDocs.org);
- ❖ American Institute of Architects (AIA) (www.aia.org/contractdocs/index.htm);
- ❖ Engineers Joint Council Document Committee (EJCDC) (www.ejcdc.org/); and
- ❖ Design Build Institute of America (DBIA) (www.dbia.org/resource-center/Pages/Contracts.aspx).

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Standard contract forms

- ❑ AIA Contracts, developed by the American Institute of Architects (AIA):
- ❑ ConsensusDocs, **developed by 40 leading associations** in the construction industry;



AIA Documents

Standard contract forms

- ☐ **Contracts** should **not be signed** until they have been subjected to a thorough legal review.
- ☐ This is to ensure that the
 1. Documents are **legally enforceable** in the event of a disagreement
 2. There is a clear, legal description of **each party's responsibilities**
- ☐ The **advantage of using** standard government or professional copyright contract forms is that they
 1. **Have been developed** by individuals skilled at contract law
 2. Have been tested in and out of courts

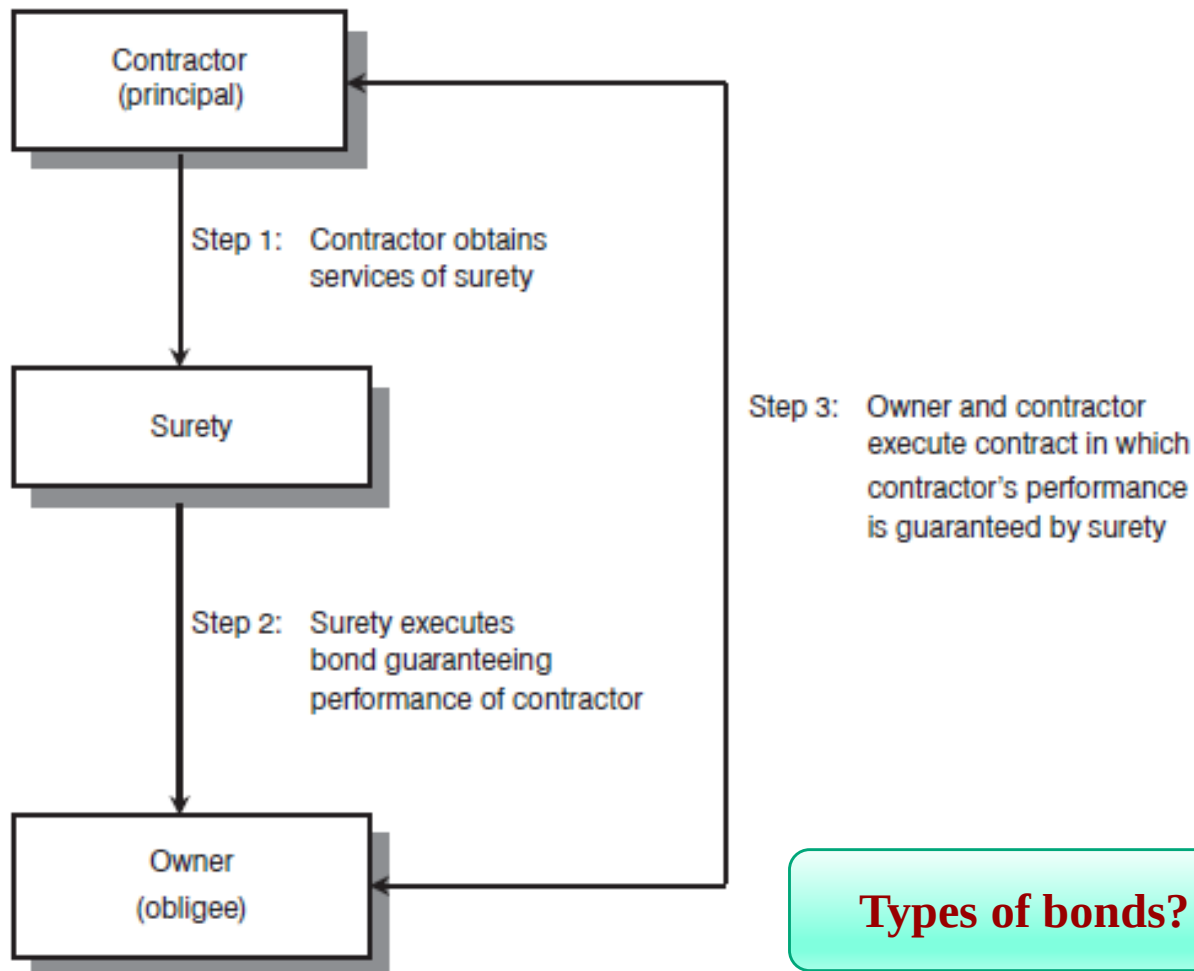
Care should be exercised when modifying any of these standard forms.

BONDS

Bond usage

- ☐ Bonds are used to **protect the owner** from some of the **risks associated** with construction.
- ☐ The concept of a bond is that a **third party (called the surety)** **guarantees** to the owner that the **contractor** will perform the work appropriately.
- ☐ **When** the **contractor completes** its obligations under the terms of the contract, the bond expires.
- ☐ **Most public owners** require bonds on projects exceeding a certain value, such as \$250,000.
- ☐ **Similar bonds** also may be required by **general contractors** to guarantee the performance of **subcontractors**.

Relationship between owner, surety, and contractor



Types of bonds?

Types of bonds

❑ There are **four types** of bonds typically used in construction:

1. **Bid bond**: guarantees that the **low bidder** will

a) **Submit** performance and payment bonds and

b) **Execute** a contract to complete the project at the price bid.

❖ If the contractor does not, the **bid bond** becomes **payable to the owner** as compensation for **damages sustained**,

which are the **additional costs incurred** by awarding the contract to the **next lowest bidder**.

An example of a bid bond is shown in next slide.

Bond No. BQ-157

KNOW ALL BY THESE PRESENTS, that we, Northwest Construction Company of Cascade, Washington (herein called the Principal) as Principal and American Surety Company, a New York Corporation of New York, New York (herein called the Surety) as Surety are held and firmly bound unto the City of Seattle (herein called the Obligee) in the penal sum of nine hundred eighty-five thousand dollars (\$985,000) for the payment of which the Principal and the Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that WHEREAS the Principal has submitted a bid to the Obligee on a contract for construction of the Sand Point Library.

NOW, THEREFORE, if the said contract be timely awarded to the Principal and if the Principal shall, within such time as may be specified, enter into the contract and give Bond with surety acceptable to the Obligee for performance of said contract, then this obligation shall be void; otherwise to remain in full force and effect.

Signed and sealed this fifth day of January, 2017.

Harry P. Jones
(Witness)

Samuel T. White
(Witness)

Sam Peters
Sam Peters, Vice President
Northwest Construction Company
(Principal)

Terry L. Johnson
Terry L. Johnson, Attorney-in-Fact
American Surety Company
(Surety)

Standard contract forms

❑ There are four types of bonds typically used in construction:

2. **Performance bond**: guarantees that the contractor will **complete the project** in accordance with the contract plans and specifications.
- ❖ If the **contractor fails** to perform or defaults, the **bonding company** either
 - a) Must **complete the project** in accordance with contract requirements or
 - b) Must **compensate** the owner for additional costs incurred by **hiring another contractor** to complete the project.

An example performance bond is shown in next slide.

American Surety Company
126 William Street
New York, New York 10038

Bond No. BP-157

KNOW ALL BY THESE PRESENTS, that we, Northwest Construction Company of Cascade, Washington (herein called the Principal) as Principal and American Surety Company, a New York Corporation of New York, New York (herein called the Surety) as Surety are held and firmly bound unto the University of Washington (herein called the Oblige) in the penal sum of sixty-one million, twenty-four thousand dollars (\$61,024,000) for the payment of which the Principal and the Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that WHEREAS the Principal has entered into a written contract with said Oblige, dated March 24, 2015, for the NanoEngineering Building in accordance with the terms and conditions of said contract, which is hereby referred to and made a part hereof as if fully set forth herein.

NOW, THEREFORE, if the Principal shall promptly and faithfully perform said contract and reimburse the Oblige for all loss and damage sustained by reason of failure or default on the part of the Principal, then this obligation shall be void; otherwise to remain in full force and effect.

Signed and sealed this twenty-fourth day of March, 2015.

Harry P. Jones
(Witness)

Samuel T. White
(Witness)

Sam Peters
Sam Peters, Vice President
Northwest Construction Company
(Principal)

Terry L. Johnson
Terry L. Johnson, Attorney-in-Fact
American Surety Company
(Surety)

Standard contract forms

❑ There are four types of bonds typically used in construction:

3. **Labor and material payment bond**: guarantees that the **contractor will pay** all suppliers, and subcontractors and that **no liens** will be placed on the completed project.
- ❖ If the **contractor is unable or refuses** to **pay for work performed** or **materials used** on the project,
the **surety will pay the claimants.**

An example labor and material payment bond is shown in next slide.



Labor and material payment bond

American Surety Company
126 William Street
New York, New York 10038

Bond No. LM -157

KNOW ALL BY THESE PRESENTS, that we, Northwest Construction Company of Cascade, Washington (herein called the Principal) as Principal and American Surety Company, a New York Corporation of New York, New York (herein called the Surety) as Surety are held and firmly bound unto the University of Washington (herein called the Obligee) in the penal sum of sixty-one million, twenty-four thousand dollars (\$61,024,000) for the payment of which the Principal and the Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that WHEREAS the Principal has entered into a written contract with said Obligee, dated March 24, 2015, for the NanoEngineering Building in accordance with the terms and conditions of said contract, which is hereby referred to and made a part hereof as if fully set forth herein.

NOW, THEREFORE, if the Principal shall promptly and faithfully make payment to all Claimants for all labor and material used or reasonably required for use in the performance of the contract, then this obligation shall be void; otherwise to remain in full force and effect.

Signed and sealed this twenty-fourth day of March, 2015.

Harry P. Jones
(Witness)

Sam Peters
Sam Peters, Vice President
Northwest Construction Company
(Principal)

Samuel T. White
(Witness)

Terry L. Johnson
Terry L. Johnson, Attorney-in-Fact
American Surety Company
(Surety)

Standard contract forms

❑ There are four types of bonds typically used in construction:

4. **Maintenance bond (sometimes called a warranty bond):** guarantees that the **contractor will return** to the completed project and repair or replace any **defective or inferior materials or workmanship** during the specified warranty period.
- ❖ **Maintenance bonds** may be **required by project owners** for components with warranties that exceed the normal 1-year warranty, such as a 15-year warranty on a roof.

An example maintenance bond is shown in next slide.

Maintenance bond

American Surety Company
126 William Street
New York, New York 10038

Bond No. MT-145

KNOW ALL BY THESE PRESENTS, that we, Northwest Construction Company of Seattle, Washington (herein called the Principal) as Principal and American Surety Company, a New York Corporation of New York, New York (herein called the Surety) as Surety are held and firmly bound unto the Emerald City Development Corporation (herein called the Oblige) in the penal sum of eight hundred fifty thousand dollars (\$850,000) for the payment of which the Principal and the Surety bind themselves, their heirs, executors, administrators, successors and assigns, jointly and severally, firmly by these presents.

THE CONDITION OF THIS OBLIGATION IS SUCH, that WHEREAS the Principal has entered into a written contract with said Oblige, dated March 18, 2016, for the Cascade Medical Office Building that provides that the Principal will furnish a bond conditioned to guarantee the roof of said facility for a period of 10 years against all defects in workmanship and materials which may become apparent during said period, said contract, which is hereby referred to and made a part hereof as if fully set forth herein, and

WHEREAS said contract was completed on January 4, 2017.

NOW, THEREFORE, if the Principal shall promptly and faithfully make good, repair, and replace at its own expense any defects discovered prior to January 4, 2028 in work done or material furnished under said contract relating to the roof, then this obligation shall be void; otherwise to remain in full force and effect.

Signed and sealed this fourth day of January, 2017.

Harry P. Jones
(Witness)

Sam Peters
Sam Peters, Vice President
Northwest Construction Company
(Principal)

Samuel T. White
(Witness)

Terry L. Johnson
Terry L. Johnson, Attorney-in-Fact
American Surety Company
(Surety)

Sample bond rate schedule

<i>Contract price</i>	<i>Premium cost per \$1,000 of contract price for the first 12 months of a project (Additional Time Would Add Additional Cost)</i>
\$1 to \$100,000	\$30
Next \$400,000	\$20
Next \$1,000,000	\$15
Next \$2,000,000	\$10
Next \$2,000,000	\$7
Next \$2,000,000	\$6
Over \$7,500,000	\$5

INSURANCE

- ❑ **Insurance** is purchased by the **contractor** to cover some of the **risks associated** with the project.
- ❑ An insurance policy is a two-party contract under which the insurer (insurance company) promises,
for a **consideration (fee or premium)**,
to assume the **financial responsibility** for a specified loss or liability for a specified time.
- ❑ The **amount of risk transferred** is limited to the amounts stipulated in the individual insurance policies.
Minimum coverage requirements generally are specified in the contract documents.

Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

1. **Builder's risk insurance:** protects the contractor in the **event** the **project** is damaged or destroyed

while **under construction**.

❖ Builder's risk insurance may be all-risk or limited to named perils such as fire, wind, hail, and explosion.

❖ All-risk insurance covers all damage unless there is a **risk exclusion** such as earthquake.

❖ Builder's risk insurance generally includes

1. Coverage of materials stored on site and
2. Coverage of materials in transit and
3. Stored off site.

Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

2. **General liability insurance:** protects the contractor against **financial losses** that may result from injuries or property losses sustained by **third parties** as a **consequence** of the contractor's activities.

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Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

3. **Property damage insurance:** protects the contractor against financial loss due to **damage** to the contractor's property, such as an office building, warehouse, or maintenance facility.

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Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

4. **Equipment floater insurance:** protects the contractor against financial loss
due to physical damage to equipment

from named **perils or all risks** and **theft**.

❖ Coverage is for

1. Owned,
2. Leased, and
3. Rented equipment not operated on streets and highways.

- ❑ The **following eight types** of insurance policies typically are purchased by the contractor:
 - 5. **Automobile insurance:** protects the contractor against claims from **another party** for bodily injury or property damage
caused by contractor owned, leased, or rented automobiles and equipment operated over the highway.
 - ❖ Coverage **may include** damages to the automobiles and equipment.

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Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

6. **Umbrella liability insurance:** provides **coverage** against liability claims **exceeding** that covered by

standard general liability or automobile insurance.

❖ *For example, a contractor may have*

1. *A **general liability insurance policy** covering up to **\$2 million per occurrence** and*
2. *An **umbrella policy** covering up to **\$50 million per occurrence**.*

Insurance

❑ The **following eight types** of insurance policies typically are purchased by the contractor:

7. **Workers' compensation insurance**: protects the contractor **from a claim** due to injury or death of an **employee** on **the project site**.

- ❖ **Workers' compensation insurance** is **no-fault insurance** in which
1. Employer cannot deny a **claim** by an **insured employee** and
 2. Employee cannot **sue** the **employer** for injuries sustained on the job

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❑ The **following eight types** of insurance policies typically are purchased by the contractor:

8. **Errors and omissions insurance:** protects the contractor **against claims**

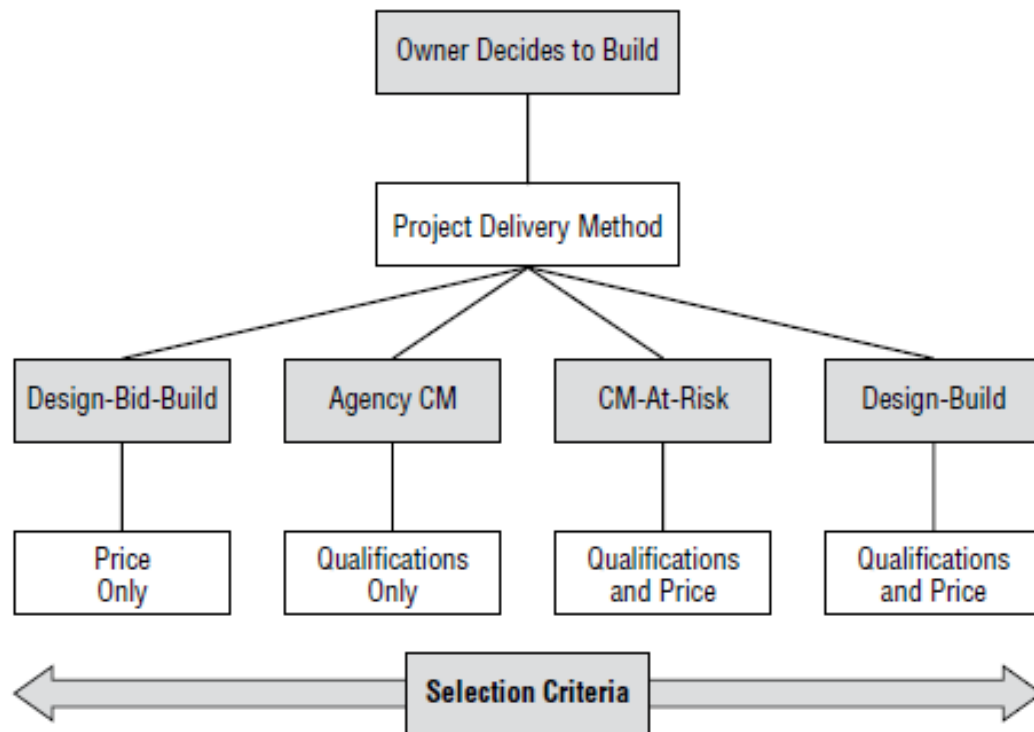
due to the professional negligence of design professionals

that the **contractor may employ**.

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PROCUREMENT METHODS

Competition criteria and project delivery



Selection methods

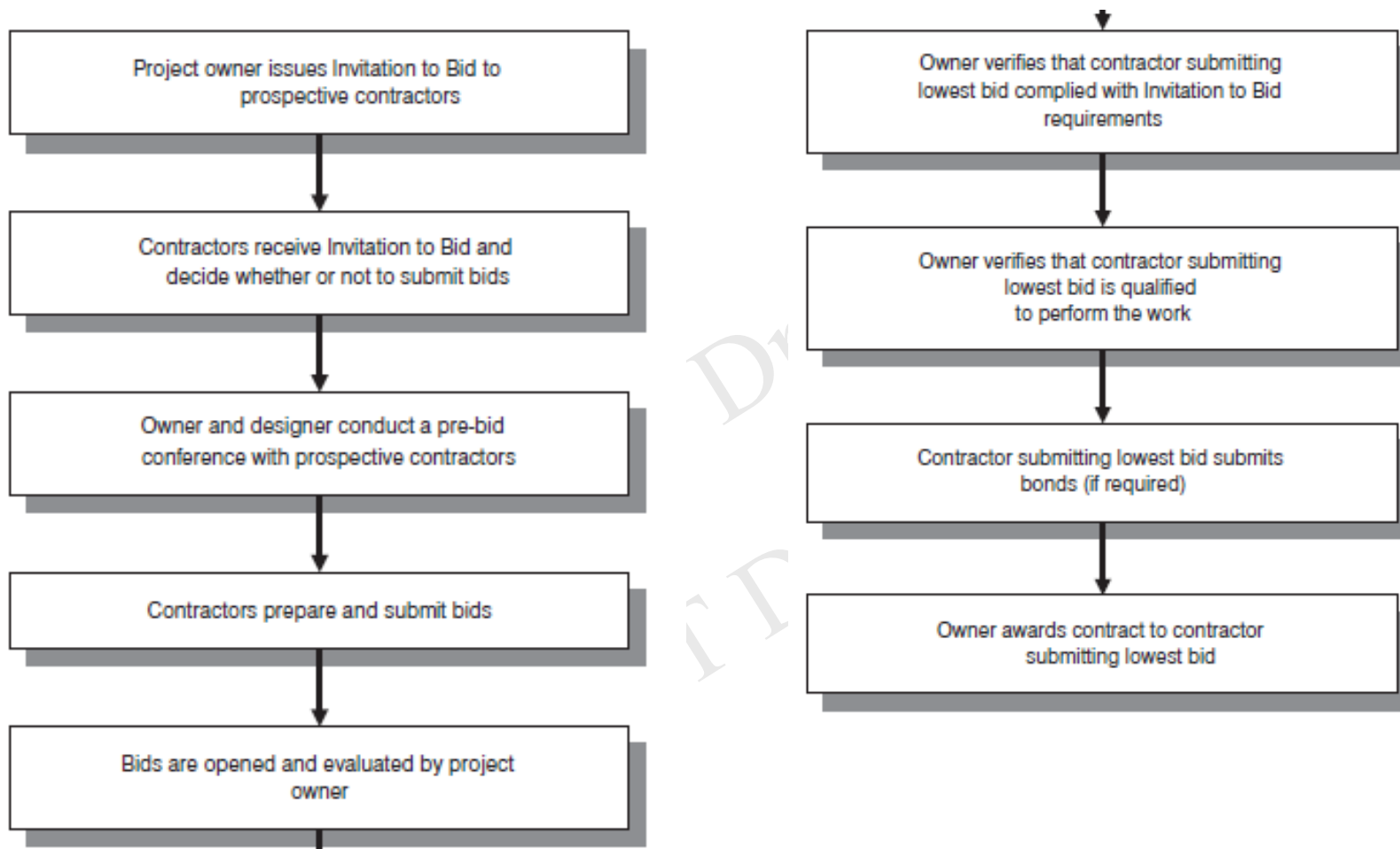
- ❑ **Once** the **owner determines** which project delivery method and corresponding competition criteria they will use,
the **framework** for the **actual selection process** has been set.
- ❑ There are basically **two selection methods** utilized for purchasing construction and construction management services:
 1. Bid method
 - ❖ Low-bid selection
 2. Negotiated method
 - ❖ Best-value selection (BVS)
 - ❖ Qualifications-based selection (QBS)

Selection methods

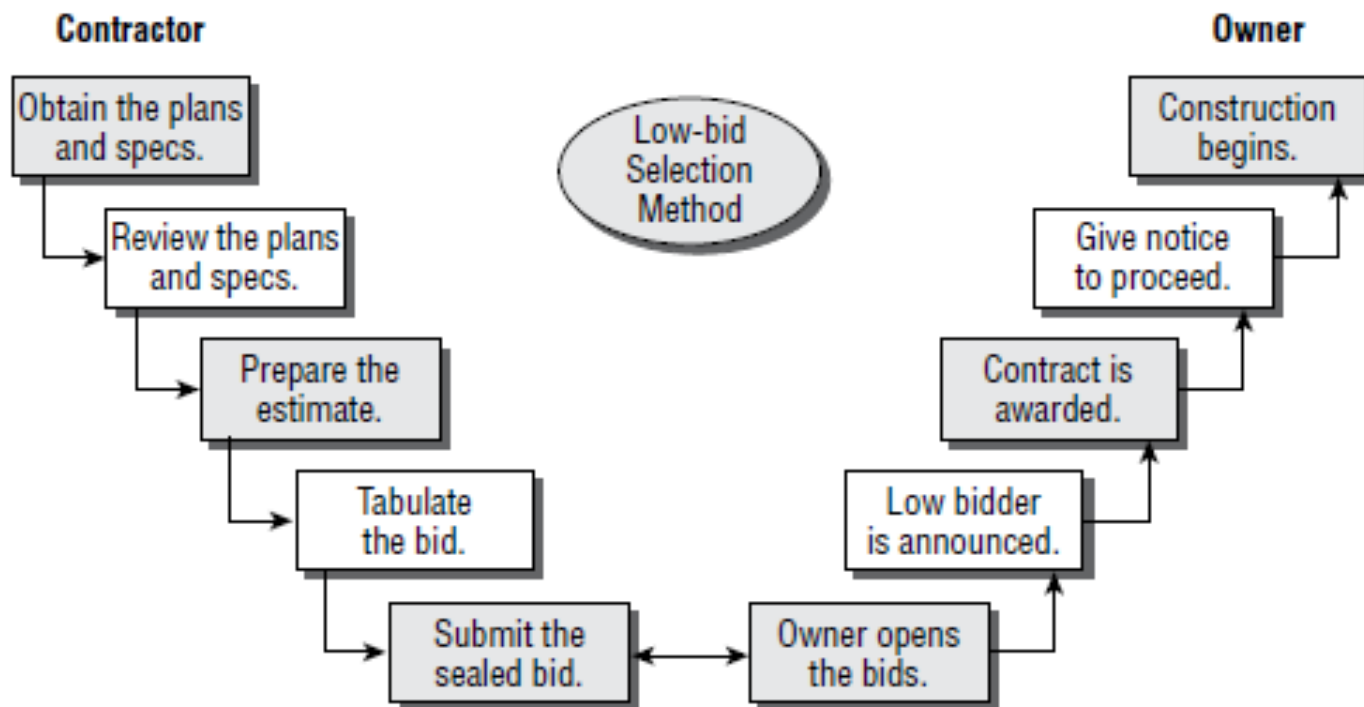
Criteria	Selection Method	Solicitation Instrument
Price only	Low-bid selection	Invitation for bids (IFB)
Qualifications only	Qualifications-based selection (QBS)	Request for qualifications (RFQ)
Qualifications and price	Best-value selection (BVS)	Request for proposals (RFP)

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Bid method – Low bid selection



Bid method – Low bid selection`



Bid method – Low bid selection

Bid Tally Sheet

Project: Administration Building Complex

ABC School District, Paso Robles, CA

Date: April 1, 20__

Bidder	Rank	Base Bid Amount	Addenda Noted		Sub List	Bid Bond	Noncollusion Affidavit	Insurance Confirm	Experience Certification
			#1	#2					
1. Acme Construction	5	\$6,789,900	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Basic Builders, Inc.	1	\$4,900,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Quality Plus Contractors	3	\$5,678,100	Yes	Yes	Yes	Yes	Yes	Yes	No
4. Build-It-Best Construction	4	\$6,100,500	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Hammer Head Construction	2	\$5,250,850	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Superior Construction, Inc.	6	\$6,940,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes

BID method – Lump sum

❑ A **lump sum contract** may require

1. **Single price** for the entire scope of work or
 2. **Separate prices** for individual portions of the scope of work.
- ❖ Some contracts may have additive or deductive items that must be **priced during** the **bidding process**.
- ✓ The owner selects which **combination** of additive and/or deductive alternates to **award once** the bids have been **opened**.

Bid method – Contract bid form containing alternates

This Figure illustrates a bid form containing additive and deductive alternates.

BASE BID

Pursuant to and in compliance with the Advertisement for Bids and Instructions to Bidders, the undersigned hereby certifies having carefully examined the Contract Documents entitled

South Central High School,
prepared by Stellar Architects

and conditions affecting the work, and is familiar with the site; and having made the necessary examinations, hereby proposes to furnish all labor, materials, equipment, and services necessary to complete the work in strict accordance with the above named documents for the sum of

_____ Dollars (\$ _____)

which sum is hereby designated as the Base Bid.

ALTERNATES

The undersigned proposes to perform work called for in the following alternates, as described in Section 010300 and the drawings of the Contract Documents, for the following resulting additions to or deductions from the Base Bid.

Alternate #1: Delete Selected Landscaping

_____ Dollars (\$ _____)

Alternate #2: Delete Paved Parking Lot

_____ Dollars (\$ _____)

Alternate #3: Add First Floor Upgrade

_____ Dollars (\$ _____)

Alternate #4: Add Second Floor Upgrade

_____ Dollars (\$ _____)

Legal Name of Bidder: _____

By: _____
Signature/Title

Date: _____

Bid method – Example

Example

A city's department of transportation is planning to solicit bids for a road project in an urban area. The three main project objectives are to get the best price, to complete the project within 150 calendar days, and to incentivize contractors who will reduce the impact of construction on road users. To this end, the owner adopts an A+B bidding procedure to select its prime contractor. Construction firms competing for this contract are invited to submit a bid amount and a project duration in calendar days. Bids that would envision a project duration longer than 150 days would be deemed not responsive and excluded. A daily monetary value of \$15,000 will be assigned to each construction day based on an estimate of road user costs. Table 5.1 shows the submitted bids by four contractors.

Table 5.1 A+B Bid Summary

Contractor	Bid Amount (A)	Project Duration in Calendar Days (B)	Road User Cost	A+B Bid
A	\$ 4,500,000	150 days	\$ 15,000/day	\$6,750,000
B	\$ 4,870,000	110 days	\$ 15,000/day	\$6,520,000
	Contract Price			Low Bid
C	\$ 4,700,000	125 days	\$ 15,000/day	\$6,575,000
D	\$ 4,200,000	180 days	\$ 15,000/day	Excluded

In this example, Contractor B has the lowest A+B bid, so a contract of \$4,870,000 would be awarded to this contractor under the agreement that the project will be completed within 110 calendar days. To incentivize on-time completion, this contract includes a *liquidated damage* (LD) clause, in that final payment to the contractor would be reduced by an amount of \$15,000 for each day of late completion.

Bid method – Contract bid form containing lump sum and unit price bid items

Some contracts may contain a combination of lump sum and unit price items as shown in this Figure

BID

Pursuant to and in compliance with the Advertisement for Bids and Instructions to Bidders, the undersigned hereby certifies having carefully examined the Contract Documents entitled

Olympic Office Tower,
prepared by Cascade Designers, Inc.

and conditions affecting the work, and is familiar with the site; and having made the necessary examinations, hereby proposes to furnish all labor, materials, equipment, and services necessary to complete the work, less the drilled pier foundations, in strict accordance with the above named documents for the sum of

_____ Dollars (\$ _____)

The undersigned proposes to furnish all labor, materials, equipment, and services necessary to construct the drilled pier foundation for the following schedule of prices. Exact quantities will be determined upon completion of the work.

Item	Est. Quantity	Unit	Unit Price	Amount
24-inch diameter drilled piers	600	linear feet		
36-inch diameter drilled piers	800	linear feet		
48-inch diameter drilled piers	900	linear feet		

Total for Unit Priced Items:

_____ Dollars (\$ _____)

Total Bid Price:

_____ Dollars (\$ _____)

Legal Name of Bidder: _____

By: _____

Signature/Title

Date: _____

Negotiated method

❑ **Negotiated contracts** are awarded based on any **criteria the owner selects**.

❑ **Typical criteria** include:

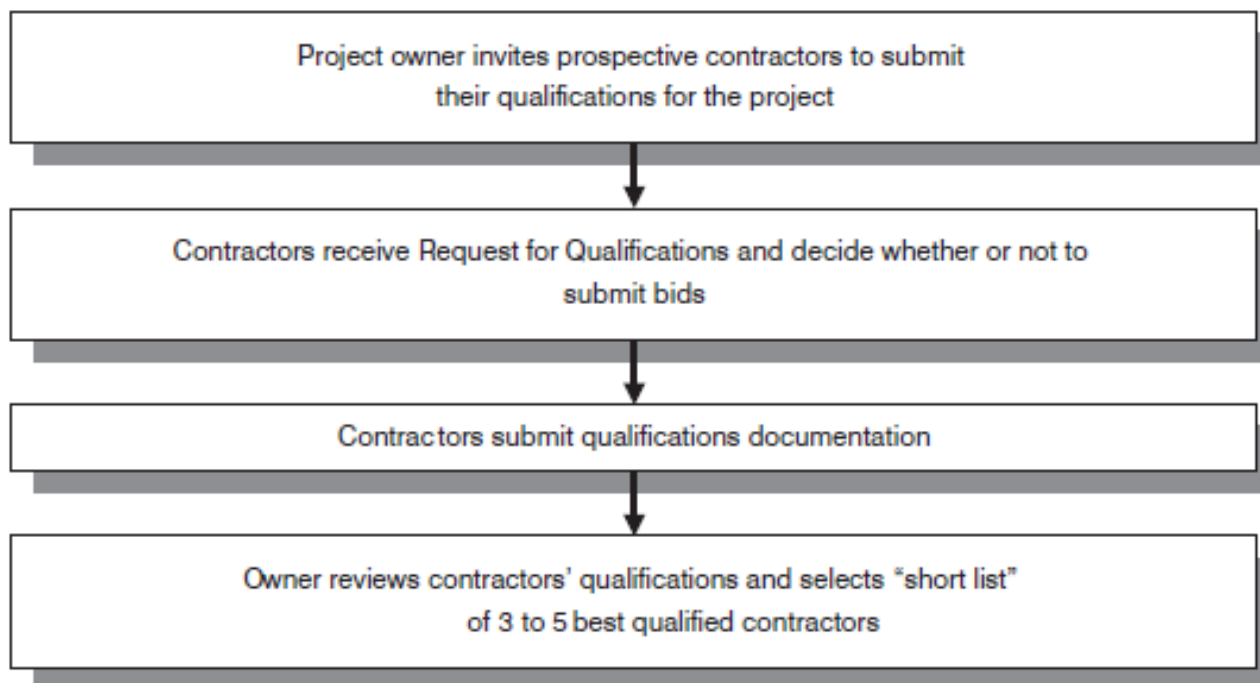
1. Cost (or fee in the case of a cost-plus contract),
2. Project duration,
3. Expertise of the project management team,
4. Plan for managing the project,
5. Contractor's safety record,
6. Contractor's existing work load, and
7. Contractor's experience with similar projects

Negotiated method

❑ **Most negotiated contracts** procured by public owners involve a **three-step procedure**.

1. First, **prospective contractors** are prequalified
after **review** of their prior work experiences and safety records.

❖ The first step or prequalification procedure is shown in Figure.



Negotiated method

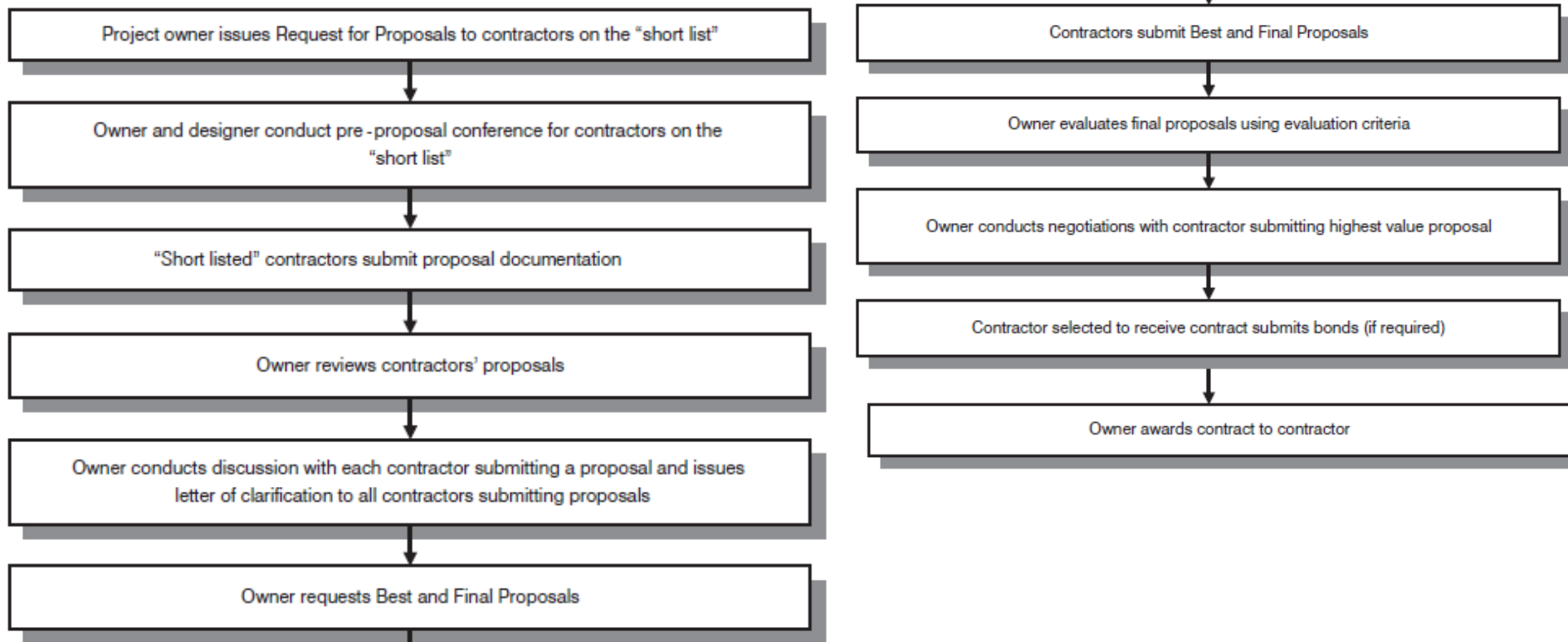
2. Then a **short list** of the most qualified contractors (**generally three to five**) are invited to **submit proposals** containing project specific information required by the owner.
- ☐ As a part of the evaluation procedure,
owners may **require** the proposed project management teams
to **brief their plans** for managing the project.
- ☐ This may include **preparation** of a project schedule and budget.

Negotiated method

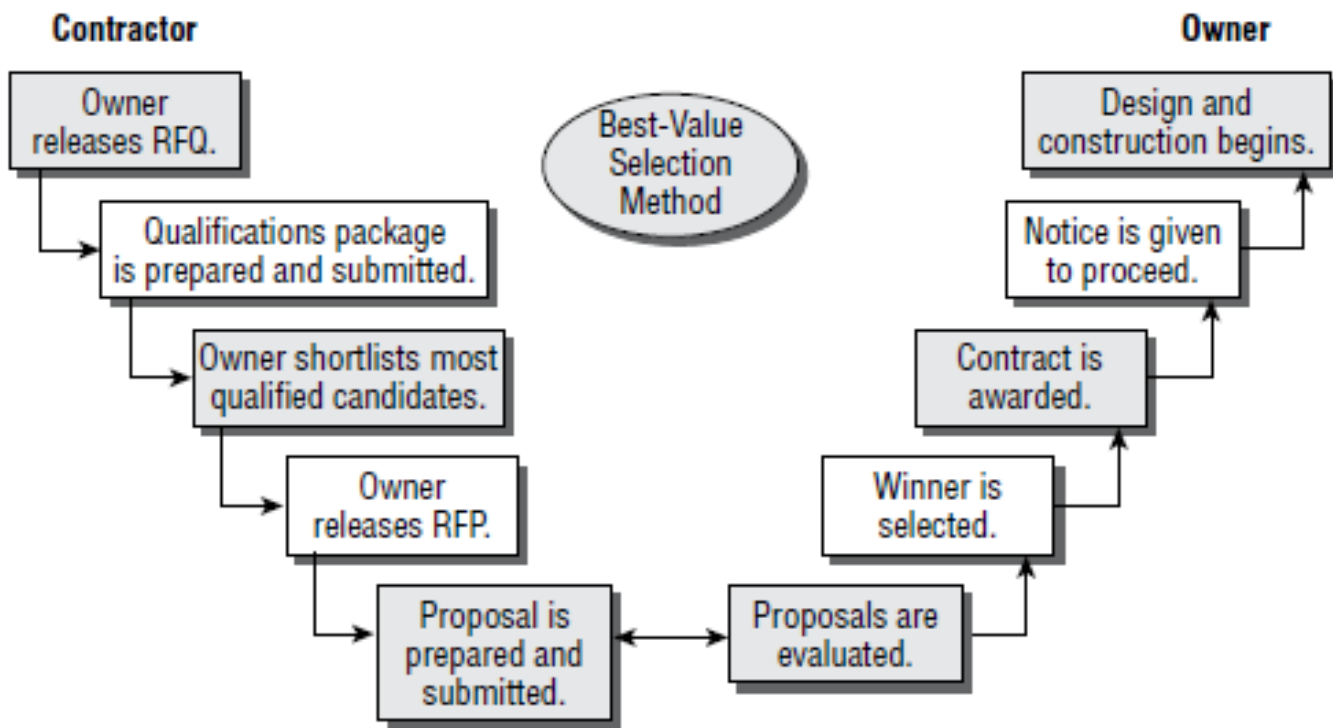
3. The **owner** then **selects** the contractor submitting the best proposal and **negotiates** a contract price, and maybe a **duration**.

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Negotiated method – Steps in awarding a contract



Negotiated method – Best value selection



Selection methods – Best value selection

best value

Any selection process in which proposals contain both price and qualitative components and the award is based upon a combination of price and qualitative considerations.

technical proposal

The part of a design-build proposal that contains the conceptual design for the project. It may also include information regarding schedule, team makeup, and overall management plan for the project.

shortlisting

Narrowing the field of offers through the selection of the most qualified proposers on the basis of qualifications.

price proposal

The part of a design-build proposal that stipulates the price at which the design-builder will provide the design and construction services necessary to complete the project.

Selection methods – Best value selection

- ☐ One of the **most common methods** for scoring the technical proposals is called weighted criteria.
- ☐ Basically, the **owner ranks** each of the criteria relative to its **importance to the project**.
- ☐ Then **each jury member** assesses a score to each team for each criterion.
- ☐ The weighted criteria are **multiplied by the score** for each factor, and a **total score** is calculated.

Negotiated method – Best value selection

Weighted Criteria Evaluation Matrix

Best-Value Proposal	Team A		Team B		Team C	
	Score	Points	Score	Points	Score	Points
Design solution (weight 10)	4	40	3	30	5	50
Financial capability (weight 8)	3	24	4	32	5	40
Energy efficiency (weight 6)	5	30	4	24	3	18
Management plan (weight 10)	5	50	4	40	4	40
TOTAL POINTS		144		126		148 WINNER

Scoring: 5 = Excellent; 4 = Good; 3 = Fair; 2 = Poor

Negotiated method – Qualification-based selection

Qualifications-based selection is sometimes called *direct selection*. Basically, an owner simply decides that they want to work with you because of your reputation and past performance. This is a position that many contractors strive for: an opportunity to be recognized and selected for the quality and professionalism of their work.

NOTE

MAKING THE BID/NO BID DECISION

Making decision to bid

Factor	Considerations
Who the owner is	Some owners are known for being easy to get along with, and others are known for being difficult. Those who have a reputation for being controlling, highly litigious, or difficult to please have a harder time getting contractors to bid their work.
Who the architect is	There are architects who are noted for the quality of their plans and specs and architects who are noted for poor-quality documents. Contractors stay away from architects with reputations for producing poor-quality plans and specs.
Location of the project	If the project is located close to the contractor's office, this usually gives the contractor a strategic advantage. The person is familiar with the local labor market, and job site overhead can be kept to a minimum. If the project is far away, then the expense to run the job goes up, and the labor market is unknown and, therefore, a higher risk. On the other hand, the contractor may want to establish a presence in a particular area to increase business opportunities associated with that market and, therefore, targets the area intentionally and makes the investment to be there.

continues

Factor	Considerations
Present workload	The contractor's workload always has an impact on when to bid and when not to bid. When there is plenty of backlog, contractors are pickier regarding which jobs they go after. Conversely, when work is slow, contractors will usually bid on jobs that they would otherwise stay away from just to keep their operations going.
Technical aspects of the job	Contractors have to assess their own technical expertise and ability to manage and supervise the work relative to the technical complexity of the work. Whenever contractors decide to bid on work with materials, equipment, or systems that are new to them, they take on greater risk.
Is it a high-profile project?	There are reasons to take on a high-profile job and reasons to stay away from them. Obviously, if contractors want to increase their own visibility and reputation, taking on a high-profile project is one way to do that. In other circumstances, such visibility may have a downside, especially on a project that is controversial to begin with.
Type of project	Contractors often become specialists in certain types of work and scout for those kinds of jobs specifically, wherever they may be located.
Size of project	Contractors are generally limited as to the size of the project that they can go after because of their bonding capacity. Larger companies are attracted to the larger projects. Smaller companies look for the smaller projects.

SUBCONTRACTING

Introduction

- ☐ General contractors **typically use subcontractors** to execute **most of the construction tasks** involved in a project.
- ☐ Typical general contractor **subcontracts 80 percent to 90 percent** of the project scope of work.
- ☐ Residential contractors may **subcontract 100 percent** of their scopes of work.
- ☐ Some industrial and highway general contractors may **self-perform most** of their scopes of work.

Subcontracting challenges

- ❑ The **major subcontracting challenges** to be faced are:
 - ❖ Defining well-understood, specific scopes of work;
 - ❖ Selecting qualified subcontractors;
 - ❖ Negotiating fair prices for the subcontracted scopes of work;
 - ❖ Scheduling and coordinating subcontractor work to ensure timely completion of the project;
 - ❖ Causing precedent subcontractors to perform their work on time and in accordance with
 - ❖ Contract requirements;
 - ❖ Resolving technical issues involving subcontractors' work;
 - ❖ Ensuring the quality of subcontractors' work;
 - ❖ Paying subcontractors on time for properly completed work; and
 - ❖ Developing enduring relationships with reliable subcontractors.

Subcontract documents

- ☐ The subcontract describes the **agreement** between the **general contractor** and **each specialty contractor** used on the project.
- ☐ It **usually is based** on the requirements and specifications contained in the **general contract** with the **project owner**.
- ☐ **Once the scope of work** has been established, the specific terms and conditions are defined for each subcontract.

Subcontract documents

❑ Topics that should be addressed are:

- ❖ Subcontract price,
- ❖ List of subcontract documents,
- ❖ Commencement and progress of work,
- ❖ Availability of temporary utilities,
- ❖ Jobsite cleanup requirements,
- ❖ Requirement for daily report,
- ❖ Availability of lifting support and scaffolding,
- ❖ Insurance,
- ❖ Indemnification,
- ❖ Bonds (if required),
- ❖ Safety,

Subcontract documents

❑ Topics that should be addressed are:

- ❖ Disposal of hazardous waste,
- ❖ Inspection and acceptance of completed work,
- ❖ Change order procedures,
- ❖ Claims procedures,
- ❖ Payment procedures,
- ❖ Warranty,
- ❖ Dispute resolution, and
- ❖ Termination or suspension.

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Subcontract documents

- ❑ **Standard subcontract documents** have been developed by the American Institute of Architects and ConsensusDocs.
- ❑ **Project managers** should use one of these documents,
because they are **used widely** in the industry and **understood by specialty contractors**.
- ❑ The advantage of using copyright documents is that
they have been tested in court and found legally sufficient.
- ❑ **Project managers** who choose not to use one of these standard subcontracts
should **consult with legal counsel** when crafting subcontract language.

Developing your own subcontracts is very risky and not recommended.

Subcontractor prequalification

- ❑ Potential subcontractors should be evaluated using a **standard set of criteria**, such as:
 - ❖ Experience and technical skills required;
 - ❖ Technical and supervisory competency of management and field supervisors;
 - ❖ Stability and financial strength;
 - ❖ Adequacy of specialized equipment and labor;
 - ❖ Past safety performance; and
 - ❖ Reputation for working cooperatively, proven history of responding to warranty calls, and past project performance.

Subcontractor prequalification

- ❑ **One technique** for gathering much of this information is to require **prospective subcontractors** to respond to a detailed questionnaire, such as the example illustrated in next slide.
- ❑ **Additional information** should be acquired by personal interviews.
- ❑ **Owners and designers** should be **invited to participate** in reviewing the prospective subcontractors' qualifications.
- ❑ **Specialty contractors** reviewed during prequalification should be **evaluated against a set of criteria** similar to that listed in the preceding slide.



Subcontractor questionnaire

NORTHWEST CONSTRUCTION COMPANY
1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

SUBCONTRACTOR QUESTIONNAIRE

1. General Company Information:

Name: *Pacific Mechanical*

Address: *270 SW 41st Street*

City: *Renton*

State: *WA*

Zip: *98057*

Telephone: *425-251-1562*

FAX: *425-251-1580*

Type of firm. (check appropriate box)

☒ Sole owner. Name: *Joe Johnson*

☐ Partnership. List names of partners.

☐ Corporation.

President: _____

Vice President: _____

Number of years in business under present name: *20 years*

Trade(s) normally performed by company: *HVAC, ductwork, plumbing, fire protection, and sometimes controls.*

Number of trade and office personnel currently employed:

Trade employees: *200* Office employees: *12*

2. Financial Information:

What is the maximum dollar value of work the company is capable of handling at one time?

\$25,000,000

Attach last 2 years audited financial statements at end of questionnaire.

3. Insurance Information:

What is the company's workers' compensation experience modification rate for the 3 most recent years?

2012: 1.2

2013: 0.8

2014: 0.6

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Subcontractor questionnaire

How much insurance coverage does the company currently carry?

	Yes	No	Amount
General Liability	X		\$10,000,000
Automobile Liability	X		\$10,000,000
Workers' Compensation	X		As Required by State

4. Safety Information:

Does the company have a written safety program? Yes

Use your OSHA Form 200 to complete the following table.

	2012	2013	2014
Total Number of Workers' Compensation Claims	5	4	3
Number of Lost Time Workers' Comp. Claims	5	4	2
Number of Accident Liability Claims	1	0	0
Number of Fatalities	0	0	0

5. Project Information:

List current, ongoing projects with approximate dollar value and estimated completion date.

Project	Amount	Completion Date
Key Bank Building	\$8,570,000	November 19, 2015
South Shore School	\$5,650,000	January 8, 2016
Eastside Apartments	\$2,500,000	March 20, 2016

Has the company failed to complete any work assigned to it during the past 5 years? No
If Yes, explain:

Attach a list of projects completed in the last 3 years and a list of contractor references whom we may contact.

6. Equipment Information:

Attach a list of owned construction equipment with capacity, age, type, and attachments.

This questionnaire was completed by:

Name: Joe Johnson

Title: Owner

Signature: Joe Johnson

Date: July 21, 2015

Subcontractor selection

- ❑ The **recommended strategy** is to select the top-ranked five or six specialty contractors identified during prequalification and **invite them** either to
 1. Submit a proposal or
 2. Bid (quotation)for the scope of work.
 - ❖ Requests for **proposal** typically are used for design-build or cost-plus scopes of work.
 - ❖ **Invitations** to bid are used for lump sum or unit price scopes of work.

An example invitation to bid and an example request for proposal shown in next slides.



Subcontract invitation to bid/subbid proposal

NORTHWEST CONSTRUCTION COMPANY

1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

INVITATION TO BID/SUBBID PROPOSAL

To: Pacific Mechanical
Attention: Joe Johnson
270 SW 41st Street
Renton, Washington 98057

Date: August 7, 2015

Project: NanoEngineering Building
Project Address: 4010 Stevens Way, Seattle, Washington 98195

Part 1: Invitation

Northwest Construction Company invites Pacific Mechanical to submit a bid on or before 10:00 a.m. Pacific Daylight Time on September 11, 2015 for the following subcontract work:

Provide all materials, labor, supervision, equipment, supplies, and other items necessary or required to perform all mechanical work (plumbing, HVAC, and controls) in accordance with the contract drawings, specifications, and any addenda contained in the general contract documents for the construction of the NanoEngineering Building. The intent is to provide and install a complete mechanical system that meets all code requirements.

The general contract plans, specification, general and special conditions and addenda are available online from Builders Exchange. The project designer is Zimmer Gunsul Frasca and the mechanical engineering consultant is Acme Engineering.

Part 2: Bid Proposal

Base Bid: \$14,100,000

If this bid is accepted, the Subcontractor agrees to enter into a mutually acceptable subcontract and, if required, furnish performance and payment bonds from a surety licensed in the State of Washington and acceptable to the Contractor. The cost of the bond is not included in this proposal, but will be added to the subcontract price at 1.5 % of the base bid.

This bid will remain in effect and not withdrawn by the Subcontractor for a period of 30 days or for the same period of time required by the contract documents for the Contractor in the prime bid, plus 15 days, whichever is longer.

Subcontractor: Pacific Mechanical

By: **Joe Johnson**

Title: Owner

Date: September 11, 2015



Subcontract request for proposal

NORTHWEST CONSTRUCTION COMPANY

1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

INVITATION TO BID/SUBBID PROPOSAL

To: Pacific Mechanical
Attention: Joe Johnson
270 SW 41st Street
Renton, Washington 98057

Date: August 7, 2015

Project: NanoEngineering Building
Project Address: 4010 Stevens Way, Seattle, Washington 98195

Part 1: Invitation

Northwest Construction Company invites Pacific Mechanical to submit a bid on or before 10:00 a.m. Pacific Daylight Time on September 11, 2015 for the following subcontract work:

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This bid will remain in effect and not withdrawn by the Subcontractor for a period of 30 days or for the same period of time required by the contract documents for the Contractor in the prime bid, plus 15 days, whichever is longer.

Subcontractor: Pacific Mechanical

By: **Joe Johnson**

Title: Owner

Date: September 11, 2015

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Subcontractor selection

- ❑ Once the proposals or bids have been received, they are **evaluated** to select the specific specialty contractor for each subcontract.
- ❑ To ensure each subcontractor's cost proposal is realistic, the **project manager** should have previously developed an **order-of-magnitude cost estimate** for each subcontract.
- ❑ **Unrealistically low or high bids** generally indicate that the subcontractor:
 - ❖ Was uncertain regarding the exact scope of work,
 - ❖ Found ambiguities regarding some of the conditions of work,
 - ❖ Erred when preparing the quotation, or
 - ❖ Omitted items (for low bids).

Subcontractor selection

- ☐ A **high bid** also may indicate that the **subcontractor is fully committed** on other projects and **not interested** in the work.
- ☐ Any **ambiguities regarding the scope** of work should be resolved, and **all subcontractors** should be invited to **submit new bids**.

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Subcontractor selection

- ☐ Once each **specialty contractor is selected**, the **price is entered** on the subcontract, and the agreement is **signed** by an executive from the **general contractor and the specialty contractor**.
- ☐ Once the **subcontracts are awarded** and **construction begins**, the **project manager and the superintendent** work together to
 1. Schedule and
 2. Coordinate the subcontractors' workto ensure the project is completed on time, within budget, and in conformance with contract requirements.

Subcontractor management

- ❑ The **first challenge** is to mold the subcontractors into a cohesive project delivery team.
- ❑ The **superintendent** should require **each subcontractor** to submit a daily report of its activities.
 - ❖ This provides a daily record of each subcontractor's progress and any obstacles encountered in performing the work.
 - ✓ The **requirement to submit daily reports** must be included in the terms and conditions of each subcontract.

Subcontractor management

- ☐ The **success of any project** is dependent on a **viable schedule**.
- ☐ The **superintendent** is responsible for coordinating start and completion dates with **each subcontractor**.
- ☐ They **need adequate time** to
 1. Arrange their scheduled jobs,
 2. Obtain equipment and materials, and
 3. Schedule their crews.

Subcontractor management

- ❑ This means the **superintendent must** provide adequate notice to **each subcontractor** regarding the scheduled **start date for their phase** of the work.
 - ❖ The **notice** should also **indicate** the scheduled completion date to **preclude interfering with the work** of following subcontractors.
 - ✓ This includes participating in **pull planning work scheduling** as discussed in Planning and Scheduling & Lean Courses.

Subcontractor management

- ☐ If **different subcontractors** will work concurrently on the project site, the superintendent must ensure that **they are compatible** and that each receives notice.
- ☐ All subcontractors must be aware of their **safety responsibilities** including those toward **other subcontractors working on the site**.
- ☐ The **superintendent** must ensure that the jobsite is ready for a subcontractor before scheduling him or her to start work.

The superintendent also is responsible for resolving any conflicts between subcontractors.

Subcontractor management

Even though the work is being performed by a subcontractor,
the **general contractor** is still responsible for
the quality of the work performed,
the schedule, and
jobsite safety.

Subcontractor management

- ❑ The **superintendent** should conduct preconstruction meetings with subcontractors **before allowing** them to start work on the project.

A sample agenda for these meetings is shown in next slide.

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Subcontractor preconstruction meeting agenda

Subcontractor Preconstruction Meeting Agenda

1. Introduction (Points of contact established)
2. Document status
 - Subcontract agreement signed
 - Insurance certificate received
 - Project specific safety plan received
3. Scope review
4. Work status
 - Submittal status
 - Permit status
 - Material status
5. Schedule review
6. Coordination and safety
7. Quality control
8. Field administration
 - Daily foreman's report
 - Jobsite maintenance and clean up
 - Jobsite meetings
 - Back charge notification
 - Requests for information
9. Contract administration
 - Pay requests – lien releases
 - Notification of changed conditions
 - Change order procedures
 - Close-out requirements

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Subcontractor management

- ❑ The owner and designer should be invited to **participate** in **all subcontractor preconstruction meetings**.
- ❑ This allows the **superintendent and the designer** to **evaluate the work** and establish a standard of workmanship.
- ❑ Project **site cleaning policies** also should be discussed at the **preconstruction conference**.
 - ❖ Generally, **all subcontractors** should be required to clean their work areas when they have **completed their scopes** of work.

Subcontractor management

- ❑ The **superintendent** should **walk the project**

when each subcontractor finishes its portion of the work to identify any needed rework.

- ❑ An **inspection report** similar to the one illustrated in next slide should be used to document the results of each inspection.

- ❖ This is **better than waiting** until the end of the construction and **trying to get** several subcontractors to **return and do rework**.

Subcontractor management – Project inspection report

NORTHWEST CONSTRUCTION COMPANY

1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

PROJECT INSPECTION REPORT

Project: NanoEngineering Building

Date: March 16, 2016

Subcontractor: Pacific Mechanical

Area of Work: First floor mechanical rough-in

Participants:

Tom Brown, Pacific Mechanical Foreman

Harry Jones, Acme Engineering

Jim Bates, Superintendent

Scope of Inspection:

Drywall subcontractor is ready to install drywall on the first floor, so mechanical rough-in needs to be inspected before being covered

Items Requiring Correction	Date Corrected	Date Reinspected
1. Hangers missing on water line to break room	3/18/16	3/18/16 – Bates
2. Water supply to emergency eye wash facility in Room 115 missing	3/18/16	3/18/16 – Bates

Subcontractor management

- ❑ **Situations** may arise when the **scope** of work needs to be modified.
- ❑ **All such modifications** should be documented as **subcontract change orders** to **identify clearly** the changes in scope and the impact on the subcontract price.
 - ❖ Sometimes changes affect multiple subcontractors.
- ❑ In these cases, all **affected subcontracts** must be changed appropriately.
- ❑ **Prior to negotiating** the cost of a change order, the project manager **sends a change order request** to the affected subcontractors.



Subcontractor management – Subcontractor change order request

NORTHWEST CONSTRUCTION COMPANY

1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

SUBCONTRACTOR CHANGE ORDER REQUEST

Date: July 14, 2016

SCOR No.: 003

Distribution: Richardson Electric

Attached are the following documents: Revised drawings E3.03 and E4.03

Description of Change: Install complete electrical systems in both classrooms on first floor.

Please prepare an estimate and schedule impact for the enclosed. Your response is required to be submitted to the above address, in detail, with all supporting estimating backup, no later than:

Date Due: August 2, 2016

Time Due: Noon

If a response is not received by the above date and time we will assume that the enclosed has no impact to your scheduled or estimated cost of work and will issue a change modification to your subcontract/purchase order incorporating these documents indicating no impact.

Submitted by: **Mary Peterson**, Project Engineer

File code: 9821/COP #003

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Subcontractor management – Subcontractor change order

- ❑ All change orders should be issued in written form, as illustrated in the **Figure**.

NORTHWEST CONSTRUCTION COMPANY
1242 First Avenue, Cascade, Washington 98202
(206) 239-1422

SUBCONTRACT CHANGE ORDER

Change Order Number: 003

Project: *NanoEngineering Building*
Subcontract: *Richardson Electric*

We agree to make the following change(s) in the subcontract scope of work:
Install complete electrical systems in both classrooms on first floor

Change(s) will affect the following plans and/or specifications:
Revised Drawings E3.03 and E4.03

Subject to the following adjustment to the subcontract value:

Cost of this Change: \$85,150.00
Previous Subcontract Amount: \$5,009,350.00
Revised Subcontract Amount: \$5,094,500.00
Revised Completion Date: *No change*

Contractor: NORTHWEST CONSTRUCTION COMPANY

By: **Ted Jones** Project Manager Date: August 8, 2016
Authorized Signature/Title

Subcontractor: *Richardson Electric*

By: **Rick Richardson** President Date: August 8, 2016
Authorized Signature/Title

Subcontractor management – Subcontract change order register

- ❑ A change order register such as the one shown in the Figure should be maintained for each subcontract to document all changes.

NORTHWEST CONSTRUCTION COMPANY 1242 First Avenue, Cascade, Washington 98202 (206) 239-1422 SUBCONTRACT CHANGE ORDER REGISTER Project: NanoEngineering Building Subcontractor: Richardson Electric Date Awarded: September 16, 2015				
Original Subcontract				Subcontract Value
Value				\$5,000,000.00
Change Order Number	Date of Change Order	Scope of Change Order	Change Order Value	
1	11/5/15	Revised lab layout	\$5,150.00	\$5,005,150.00
2	1/7/16	Exterior lighting	\$4,200.00	\$5,009,350.00
3	8/12/16	Classroom electrical	\$85,150.00	\$5,094,500.00
---	-----	Changes reconciliation	-----	-----

Subcontractor management

❑ **Subcontractors submit requests** for payment as their work progresses,

1. At the **end of each phase** of their work, or
2. According to the **payment schedule** provided in the subcontracts

An example subcontract payment request is shown in next slide.

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Subcontractor management – Subcontract payment request

SUBCONTRACTOR APPLICATION FOR PAYMENT

To: Northwest Construction Company
From: Hi-Gloss Painting Company
Project: NanoEngineering Building, 4010 Stevens Way, Seattle, WA 98195
Payment Request: #2
Period: August 1, 2016 to August 31, 2016

Statement of Contract Account

1. Original Contract Amount:	\$590,000
2. Approved Change Order Nos: 3:	\$5,600
3. Adjusted Contract Amount:	\$595,600
4. Value of Work Completed to Date:	\$195,000
5. Value of Approved Change Orders Completed:	\$2,500
6. Materials Stored on Site:	0
7. Value of Completed Work and Stored Materials:	\$197,500
8. Net Total to Date:	\$197,500
9. Less Amount Retained (5%):	(\$9,875)
10. Total Less Retainage:	\$187,625
11. Total Previously Certified (Deduct):	\$95,500
12. Amount Due this Request:	\$92,125

Certification of the Subcontractor

I certify that the work performed and the materials supplied to date, as shown above, represent the actual value of accomplishment under the terms of the subcontract (and all authorized changes thereto) between the undersigned and Northwest Construction Company relating to the above referenced project.

I certify that the payments have been made through the period covered by previous payments received from the contractor to all of my subcontractors and for all material and labor used in or in connection with the performance of this subcontract. I further certify that I have complied with Federal, State, and local laws insofar as applicable to the performance of this subcontract.

Furthermore, in consideration of the payments received, and upon receipt of the amount of this request, the undersigned does hereby waive, release, and relinquish all claim or right of which the undersigned may have upon the premised above described except for claims or right of lien for contract and/or change order work performed to the extent that payment is being retained or will subsequently become due.

Subcontractor: Hi-Gloss Painting Company

Date: August 29, 2016

By: *Mark Jackson*
Authorized Signature

Title: Owner



مدیریت پروژه‌های صنعت ساخت (ساختمانی، زیرساختی و صنعتی)

فصل چهارم: مدیریت برنامه‌ریزی و زمان‌بندی
برنامه‌ریزی و زمان‌بندی پروژه
کنترل زمان پروژه، به‌روزرسانی و اصلاح برنامه

ارائه دهنده:

سید محمدرضا علوی‌پور

(PhD, PMP, CMIT)

دانشگاه Illinois Tech آمریکا

What we will learn?

- ☐ Project planning
- ☐ Project scheduling concepts
- ☐ Manage time
- ☐ Project scheduling applications
- ☐ Project coordination
- ☐ CM roadmap related to this section

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PROJECT PLANNING



Introduction

- ❑ Project planning is **central** to project management.
- ❑ Planning takes place **at all stages**.
- ❑ The plan is typically very **simple in concept** (though it may be quite complex in execution), consisting of a few steps:
 - ❖ Identify the **need** as clearly as possible.
 - ❖ Determine a **budget** and **completion date**.
 - ❖ Bring together a **team** that can design and build the facility.
 - ❖ Monitor the **process** throughout the project's schedule.

Introduction

❑ In order for the **plan to be “workable,”** it requires careful **consideration of all of the activities** above and **buy- in from** all of the **construction team members**, including:

- ❖ General contractor’s officer-in-charge (OIC),
- ❖ Project manager (PM),
- ❖ Superintendent,
- ❖ Field foreman,
- ❖ Project engineer,
- ❖ Home-office staff support specialists, such as the scheduler, estimator, and quality and safety officers, and
- ❖ Subcontractors.

CPM Procedure

- ❑ Construction **time control** is a difficult, time-consuming, and arduous management function.
- ❑ The **Critical Path Method (CPM)** is just such an expedient and constitutes the **basis** for the ensuing treatment of **project time control**.
- ❑ This method applies **equally well** to
 - ❖ All construction work,
 - ❖ Large and small,
 - ❖ Intricate and straightforward

CPM Procedure

❑ CPM is a **three-phase procedure** consisting of planning, scheduling, and time monitoring or controlling.

1. **Planning** construction operations involves the determination of what must be done, how it is to be performed, and the sequential order in which it will be carried out.
2. **Scheduling** determines calendar dates for the start and completion of project components.
3. **Time monitoring** is the process of comparing actual job progress with the programmed schedule.

Planning phase

❑ Construction **planning** may be said to consist of **five steps**:

1. A **determination** of the general approach to the project.
2. **Breakdown** of the project into job steps or “activities” that must be performed.
3. **Ascertainment** of the sequential relationships among these activities.
4. **Graphic presentation** of this planning information in the form of a network.
5. **Endorsement** by the project team.

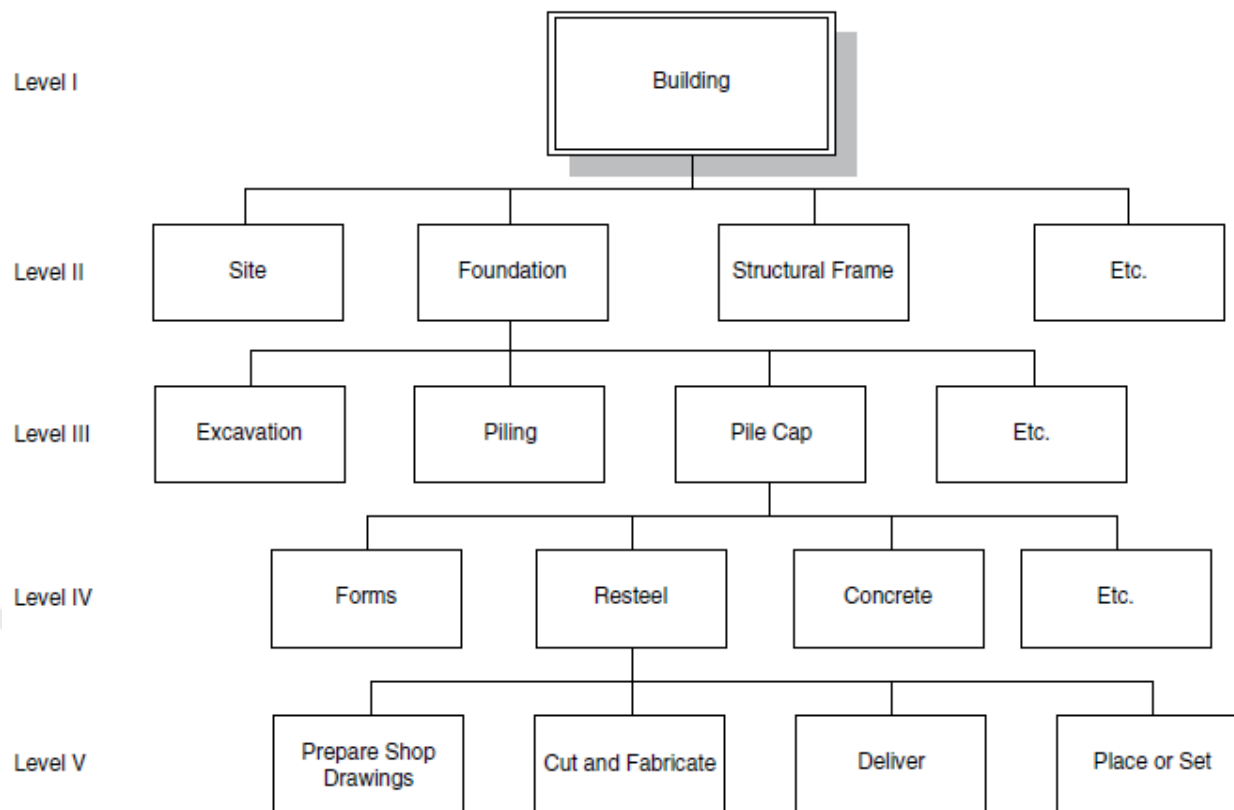
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Work breakdown structure (WBS)

- ❑ Project planning involves the **development** of an objective or facility and a scope of work defining the work product or deliverable.
- ❑ The **bid package** consisting of the plans and specifications establishes the **scope of work** to be performed.
 - ❖ To be properly managed, the **scope of work** must be broken into components that **define** work elements or building blocks, which need to be **accomplished** to realize the end objective.
- ❑ The **assumption** is that the project is the summation of its sub-elements.

Work breakdown structure (WBS) – Example

- ❑ The Figure is an example of a WBS for a small building.





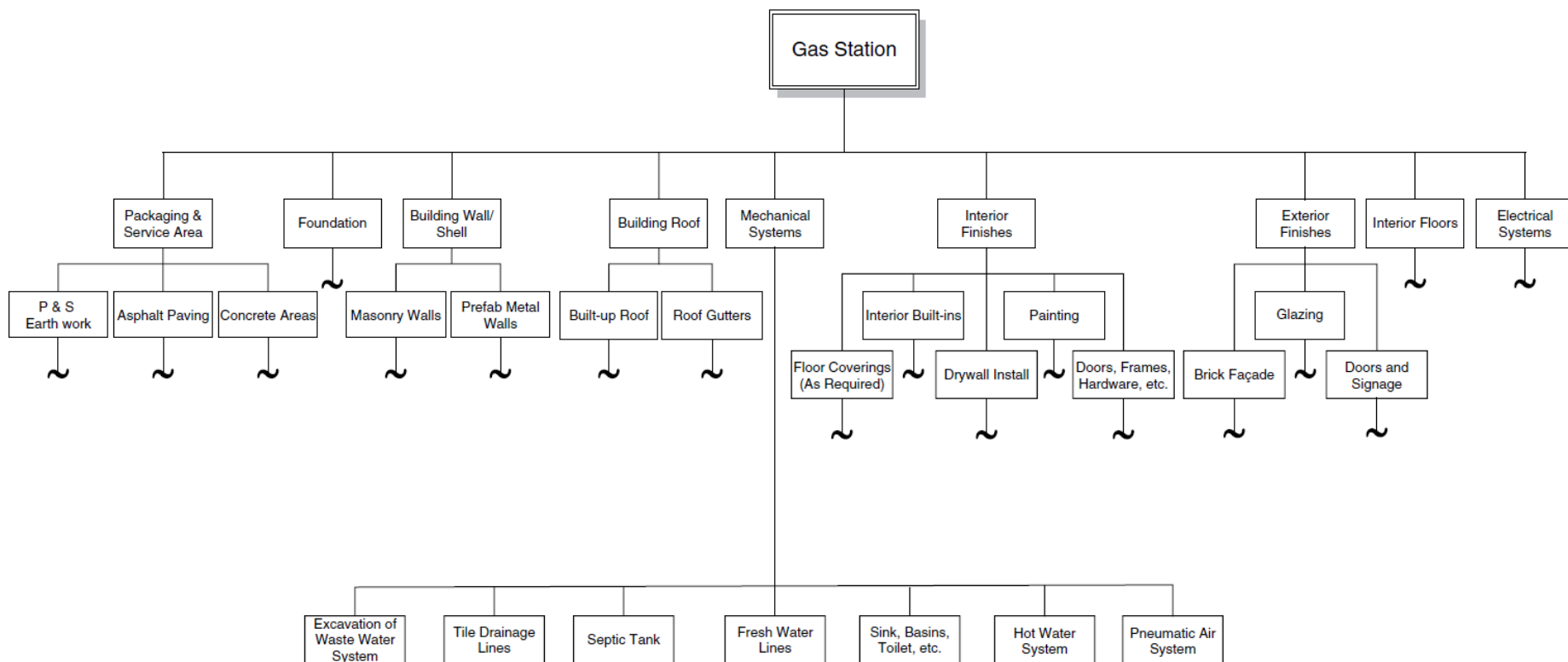
Work breakdown structure (WBS)

- Planning can be thought of as the **definition and sequencing** of the work packages within a given project. That is:

$$\text{Planning} = \text{Work Breakdown} + \text{Work Sequencing}$$

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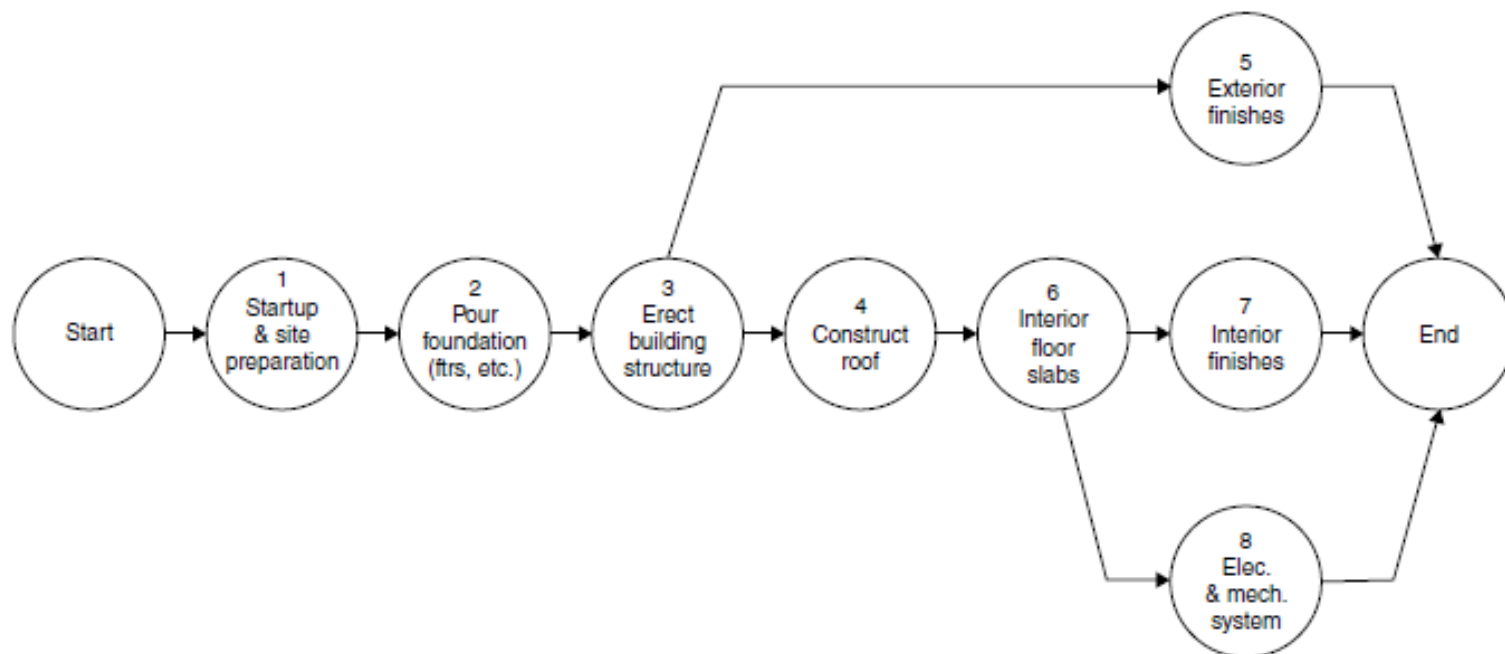
Work breakdown structure (WBS) – WBS for gas station



Determining sequence of work packages

- ❑ Having broken the work into **work packages**,
activities that **facilitate time management and control** can be
defined and logically placed in sequence.
- ❑ In **arranging the work package sequence** for time control, the criteria of
 - (a) location,
 - (b) material,
 - (c) method, and
 - (d) required resourcesmust be reconsidered from the **perspective of**
how these criteria impact the order or sequence of work activities.

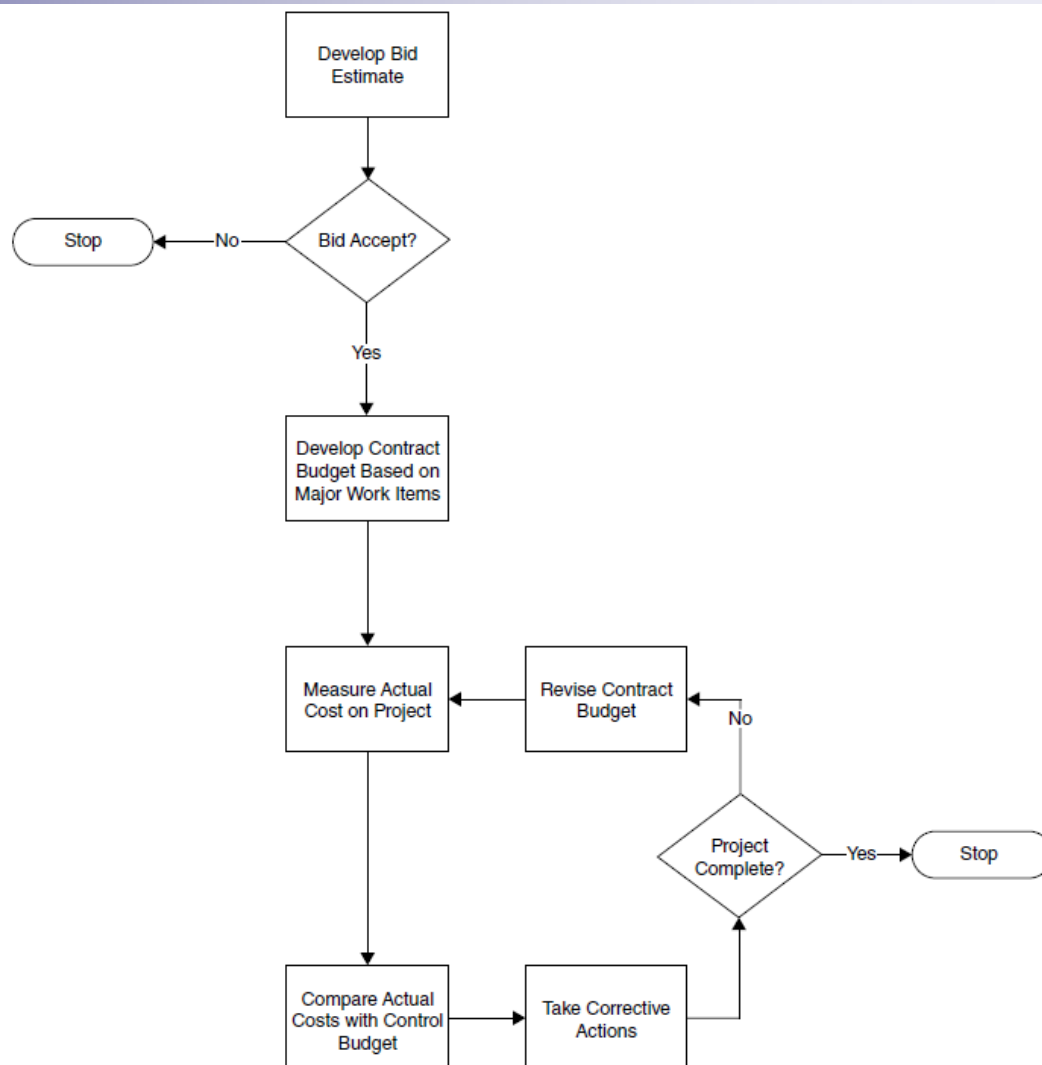
Determining sequence of work packages – Preliminary breakdown



Estimate development and cost control related to the WBS

- ❑ A **good WBS** facilitates cost control during the **life of the project**.
 - ❖ If a WBS is used, the major items are work packages.
- ❑ **Work packages** are defined so that they have their own unique budgets.
- ❑ When referring to **work packages** in the context of cost control, the terminology cost accounts or control accounts is often used.
- ❑ During the **bidding process**, the contractor prepares an estimate of cost that becomes the **basis for the bid price** submitted for the **proposed work**.
- ❑ If the **bid is accepted**, the detail estimate used for **bid submittal** is **converted to a budget** that serves as a cost baseline to control spending during the life of the project.

Estimate development and cost control related to the WBS



Role of code of accounts

❑ The development of **cost coding systems** is discussed in detail in the following course.

- ❑ A **typical cost code** might define
- (a) the project designator,
 - (b) area of work,
 - (c) work discipline (e.g., civil, mechanical, electrical, etc.), and
 - (d) the trade specialty required.



Role of code of accounts

Cost Code Structure (Example)

Level	Project	Area	Discipline	Trade
1	21300			
2		804		
3			724	
4				112

Cost Code = 21300.804.724.112

Role of code of accounts

Work Package Identification 06-123 Description: Concrete Placement Interior Floor Slabs						
	Materials					Actual Productivity
Resource Code	Description	Unit	Qty	Unit Cost	Extension	
101	Concrete, 2500psi	CY	30	40.00	1200.00	
						Notes
	Installed Equipment					
						Cost Summary
	Crew Labor	NR	Hours	Cost/Hr	Extension	
020	Foreman	1	8	30.00	240.00	
029	Laborer	4	8	15.00	480.00	
022	Finisher	1	8	20.00	160.00	Actual Cost Labor = Materials = Equipment =
063	Pump Operator	1	8	25.00	200.00	
Total					1080.00	Variation from Budget
Equipment Not Charged As Indirects						
		NR	Hours	Cost/Hr	Extension	
505	Vibrator	1	8	10.00	80.00	
517	Finisher	1	8	15.00	120.00	
308	Concrete Pump	1	8	150.00	1200.00	
						Total
					1400.00	

Work package control account sheet (CII Cost/Schedule Task Force, 1988)

Job activities

- ☐ The segments into which a **project is subdivided** for planning purposes are called **activities**.
- ☐ An **activity** is a single continuous work step
that has a recognizable beginning and end and
requires time for **its accomplishment**.

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Job activities



Activities are made up of the verb (action), noun (what), and location (where).



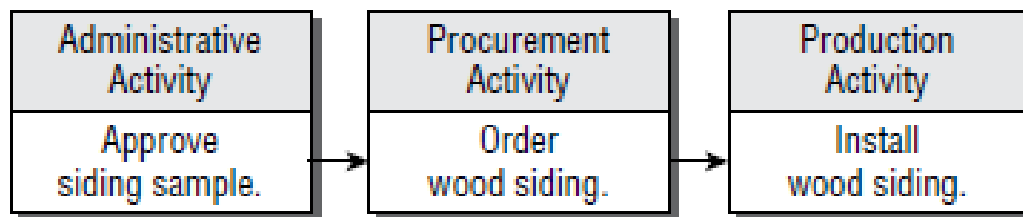
Job activities

❑ The extent to which a project is subdivided depends on a number of practical considerations, but these **eight are suggested as guidelines** for use when activities are being identified:

1. By area of responsibility, where work items done by the general contractor and each of its subcontractors are separated.
2. By category of work as distinguished by craft or crew requirements.
3. By category of work as distinguished by equipment requirements.
4. By category of work as distinguished by materials such as concrete, timber, or steel.
5. By distinct structural elements such as footings, walls, beams, columns, or slabs.
6. By location on the project when different times or different crews will be involved.
7. With regard to the owner's breakdown of the work for bidding or payment purposes.
8. With regard to the contractor's breakdown for estimating and cost accounting

purposes.

Job activities



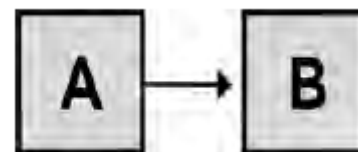
Job logic

- ❑ **Job logic** refers to the determined order in which the activities are to be **accomplished in the field**.
- ❑ The **start of some activities** obviously depends on the **completion of others**.
 - ❖ A **concrete wall** cannot be poured until the forms are up and the **reinforcing steel** has been tied.
 - ❖ **Much job logic** follows from well-established work sequences that are **usual and standard** in the trade.
 - ✓ Nevertheless, for a **project of any consequence**,
there is always **more than one general approach**, and
no unique order of procedure exists.

Who has the responsibility for this?

Job logic

- ❑ There are **various ways** that activities can be **logically linked together** to define sequence and interdependencies.
- ❑ As previously mentioned, **finish-to-start (FS)** is the most common form of relationship which means the previous task (predecessor) must be completed (finished) before the next task (successor) can start.



Job logic

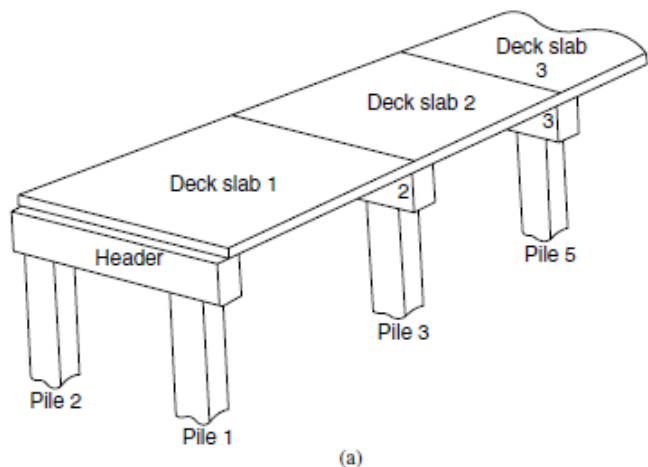
❑ Also, **logic relationships** may be in the form of

1. Hard logic, which means there is a **mandatory dependency**, or
2. Soft logic where dependency is **discretionary**.

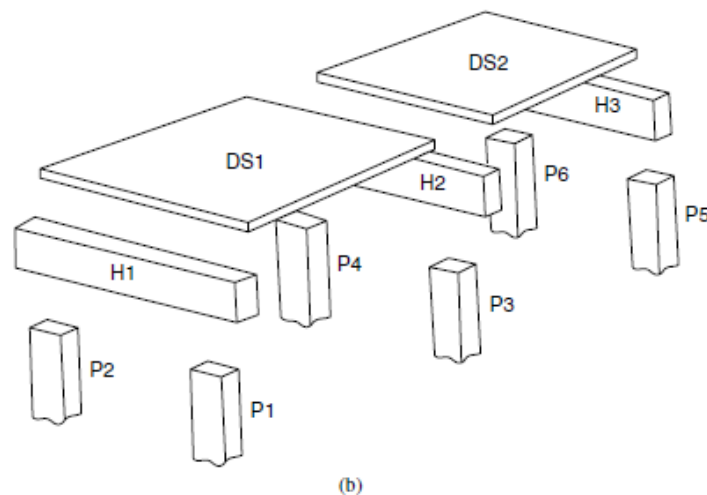
- ❖ *An example of hard logic would be activities that are related to each other based on **physical requirements** such as needing a wall before installing a roof.*
- ❖ *Soft logic refers to **managing resources (supplies and labor)**, handling cash flow, or creating a progression of activities.*



Job logic

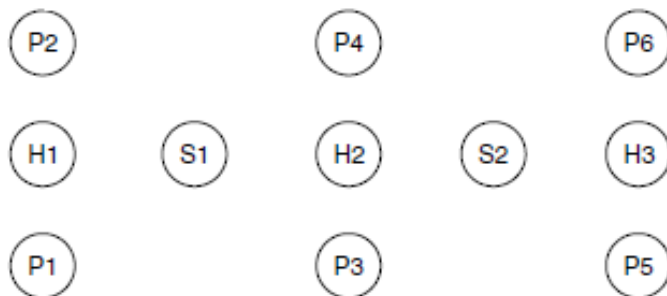


(a)

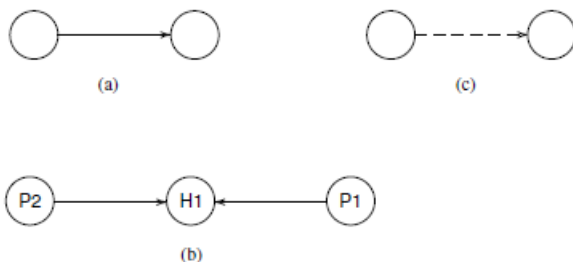


(b)

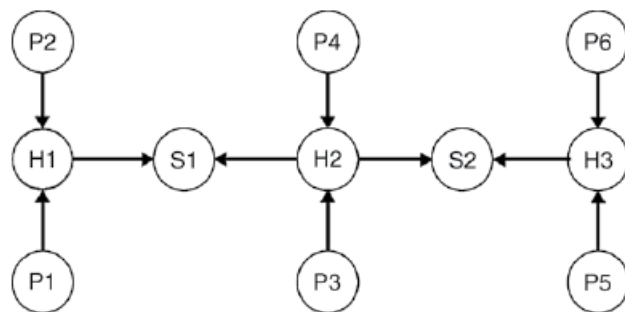
Conceptual model
of pier components



Job logic

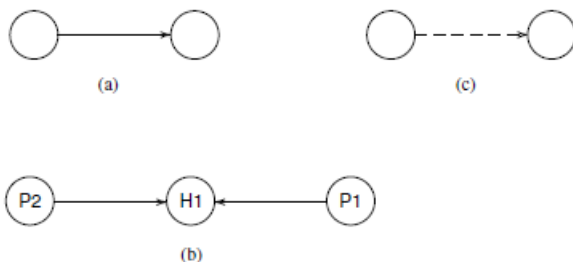


Logical modeling rationales: (a) adjacency of contact modeling; (b) physical structure order modeling; (c) physical construction order modeling

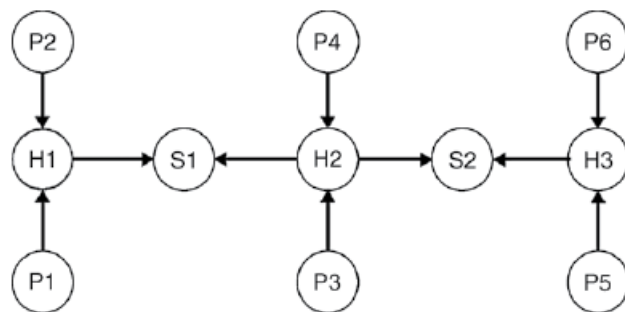


Conceptual model of pier component relationships

Job logic

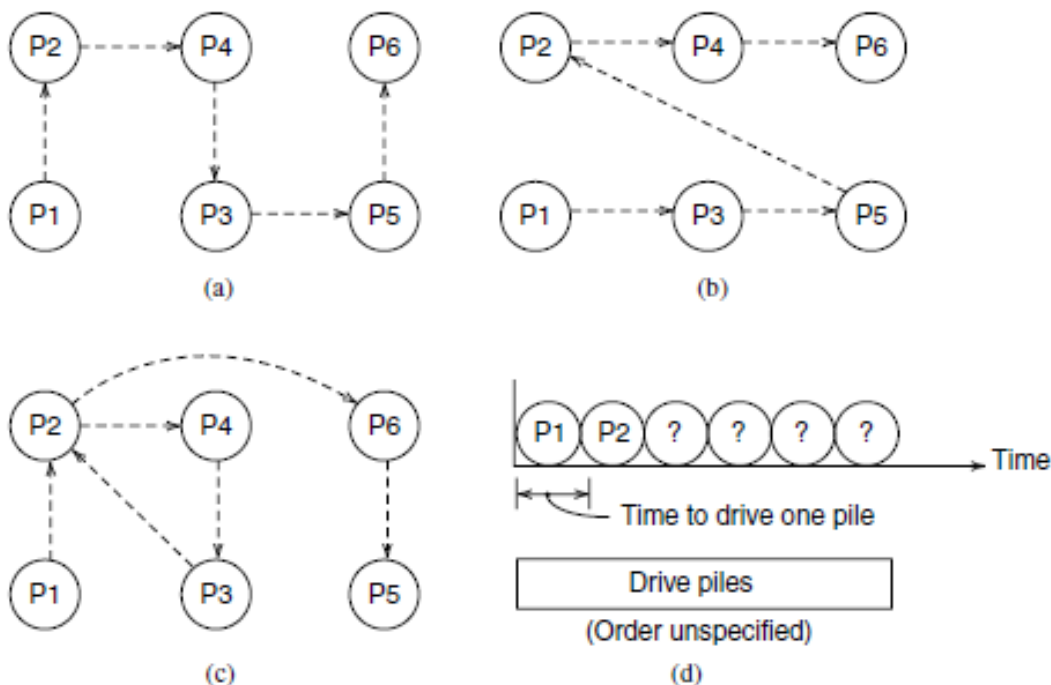


Logical modeling rationales: (a) adjacency of contact modeling; (b) physical structure order modeling; (c) physical construction order modeling



Conceptual model of pier component relationships

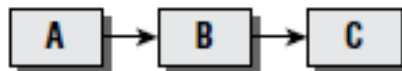
Job logic



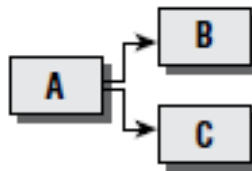
Construction sequence and activity modeling (Antill and Woodhead, 1982): (a) alternate row pile driving; (b) sequential row pile driving; (c) field mishap alteration to pile-driving sequence; (d) bar chart model of pile-driving operation

Job logic

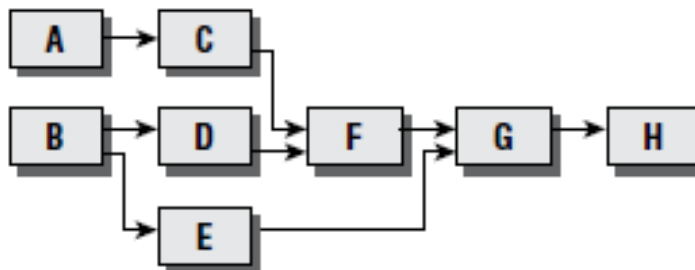
A must occur before B occurs, and C can't happen until B is complete.



A must occur before B and C can occur. B and C can occur simultaneously.



H cannot be done before G, and G is dependent upon the completion of E and F. F can't happen before C and D. D and E are preceded by B. C can't start until A is done.



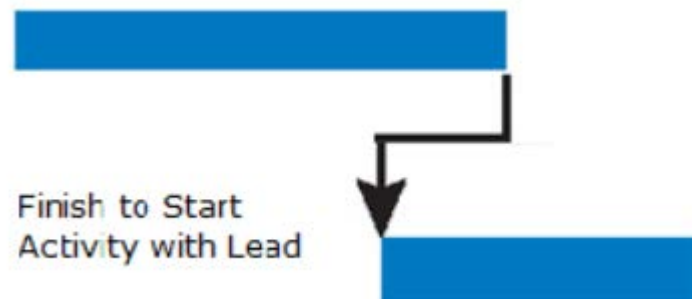
Lag relationships

❑ **Lead/Lag times** are used when **assumptions** around logic need to be introduced into the schedule.

❖ Lead time is the **overlap** between activities that have a dependency.

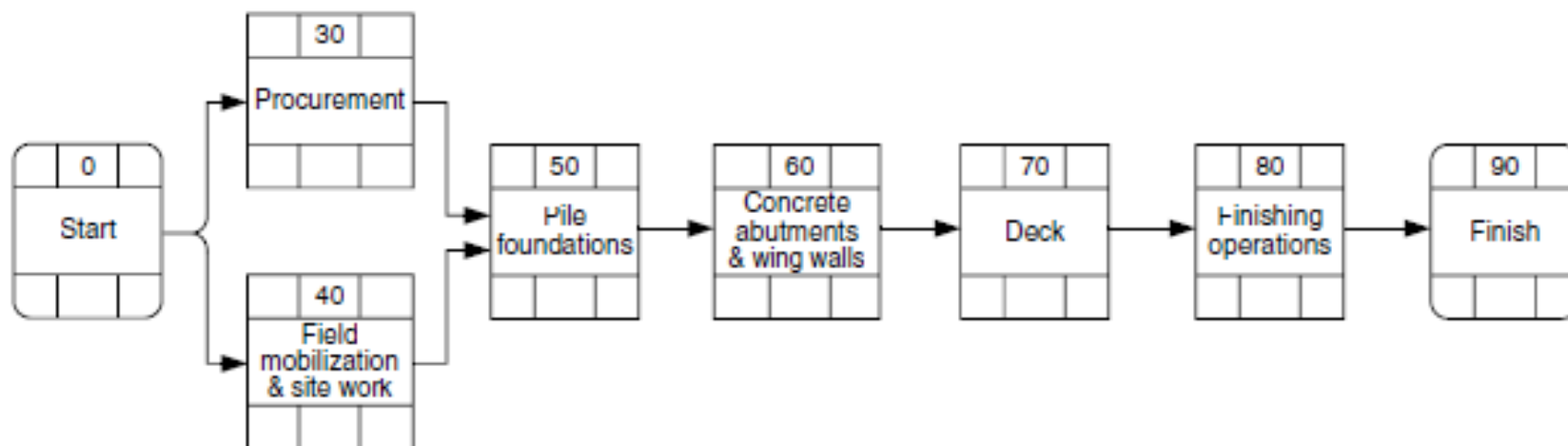
❖ Lag is a **delay between** tasks that have a dependency.

❖ *For example, if there is a three-day delay between the time one task finishes and the other one starts, that means there is a finish-to-start dependency with three days of lag time.*



Lag relationships – Highway bridge, general job plan

- ❑ The Figure has been drawn on the **customary basis** that a given **activity cannot start** until all of those activities immediately preceding it have been completed.



Restraints or constraints

- ❑ To be realistic, a job plan must reflect the **practical restraints** or **limitations** of one sort or another that **apply to most job activities**.
- ❖ The restrictions of job logic itself might be called **physical restraints**.
 - ✓ **Placing forms and reinforcing steel** might be thought of as restraints to pouring concrete.

However, there are other kinds of restraints that need to be recognized.

Restraints or constraints

- ❑ **Almost all CPM schedules** have some **type of constraints** that must be considered.
- ❑ Three types of common constraints are date, duration, and float.
 1. Date refers to the **time allotted** for an activity.
 2. An example of duration is that **all work in one phase of the project** must be **completed in 240 days**.
 3. A float constraint may be used to **limit the amount of delay (or float)** an activity can have **without delaying** the project.

*As a rule, constraints should be **used sparingly** to ensure that there is **minimal impact** to schedule calculations.*



Restraints or constraints

- ❑ Many scheduling software packages provide the option to use date-related or float-related constraints.
- ❑ The type of constraints and their operation differs between software packages, but in **general terms constraints** override the duration and logic-driven CPM calculations.
 - ❖ This makes **constraints a powerful and potentially dangerous tool**.
 - ✓ When **constraints** are applied to the CPM schedule, there is a **significant risk** that the schedule will **report misleading**
 1. Start and finish dates,
 2. Float, and
 3. Criticality.

Restraints or constraints

❑ The **first choice** should be to **avoid** the use of constraints,

but **if used**, they should be **used sparingly** and
with **caution and understanding** of the **effect** they are having on the
underlying CPM calculations.

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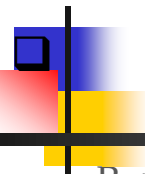
Network format

- ❑ A **horizontal diagram format** has become standard in the construction industry.
- ❑ The general synthesis of a network is from **start to finish**, from **project beginning** on the left to project completion **on the right**.
- ❑ The **sequential relationship** of one activity to another is **designated by the dependency** lines between them.

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Production planning

- ☐ Planning team
- ☐ Reengineering the project
- ☐ Planning for production
- ☐ Support planning
- ☐ Technical problems
- ☐ Personnel planning
- ☐ Safety planning
- ☐ Planning for quality
- ☐ Material ordering and expediting
- ☐ Material handling, storage, and protection
- ☐ Equipment planning



PROJECT SCHEDULING CONCEPTS

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

دفتر آموزش



تهران، بلوار فردوس شرق، مجتمع آبگینه، طبقه سوم اداری، واحد C42



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