Cost Estimating

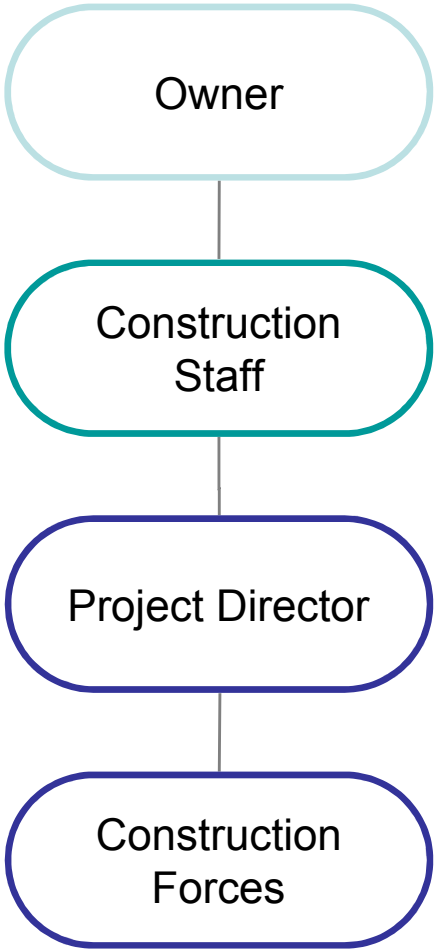
WSDOT Unit Bid Analysis

Outline

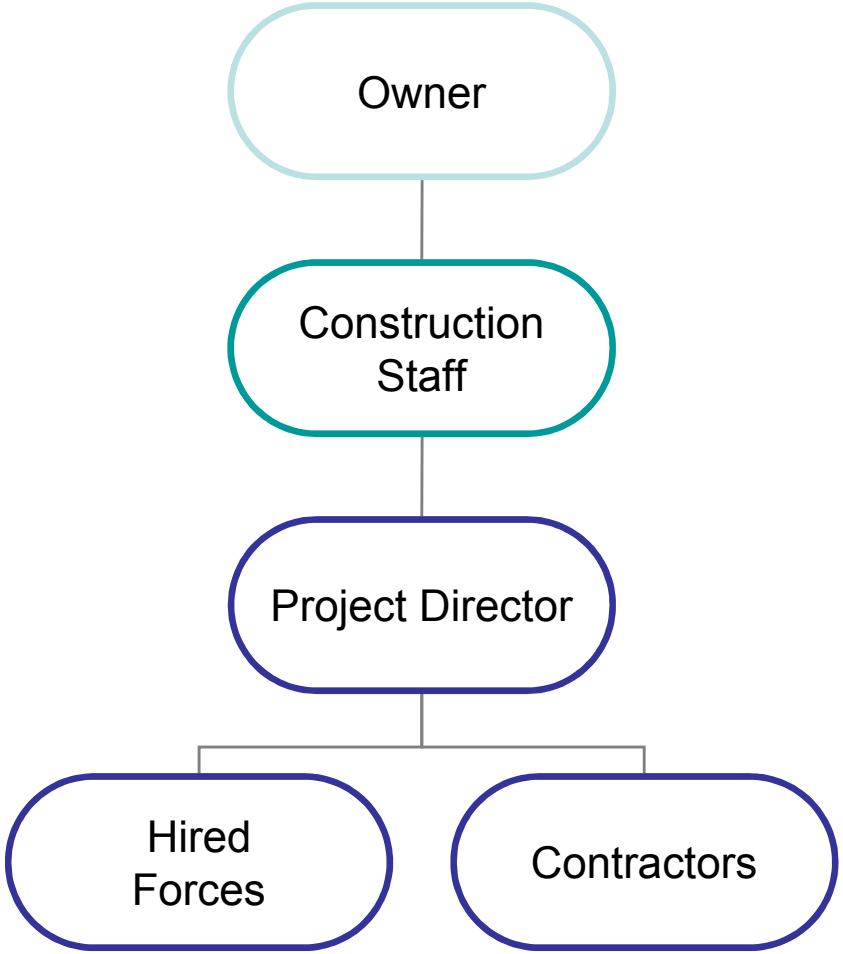
- Construction organizations (review)
- Construction contracts (review)
- Contract documents
  - Standard specifications
  - Standard specifications for DOTs
- Unit prices
  - Unit bid items
  - WSDOT Unit bid items
  - Short in-class exercise
- Quality control/acceptance
- Price adjustments

Construction Organizations

Construction Using Owner Forces

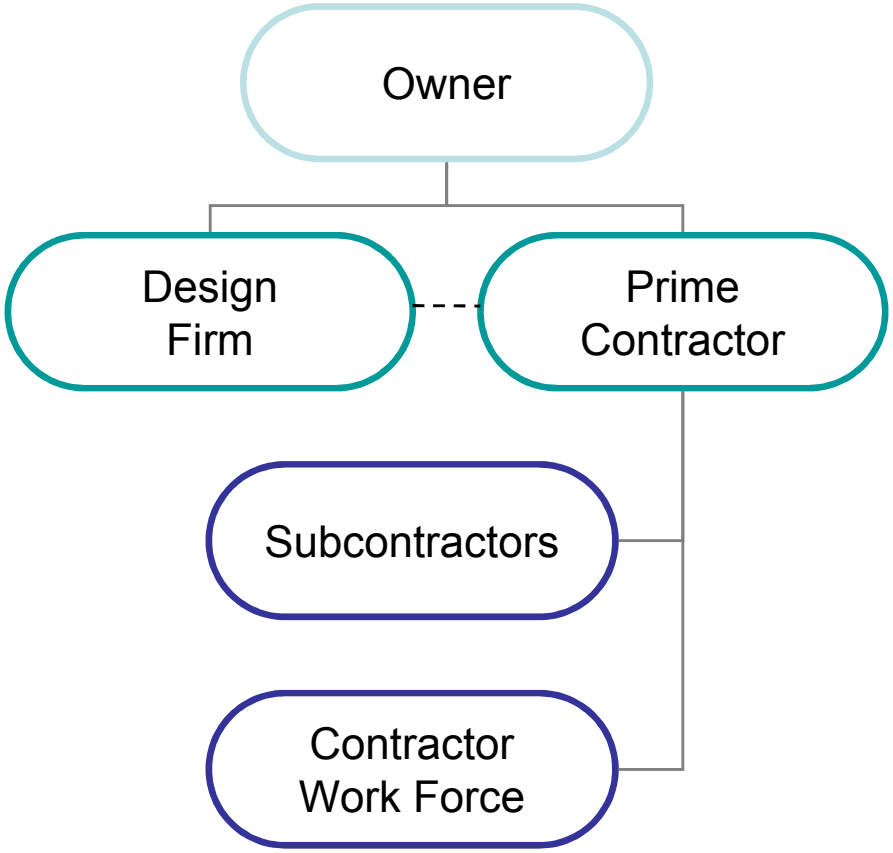


Owner-Managed Construction

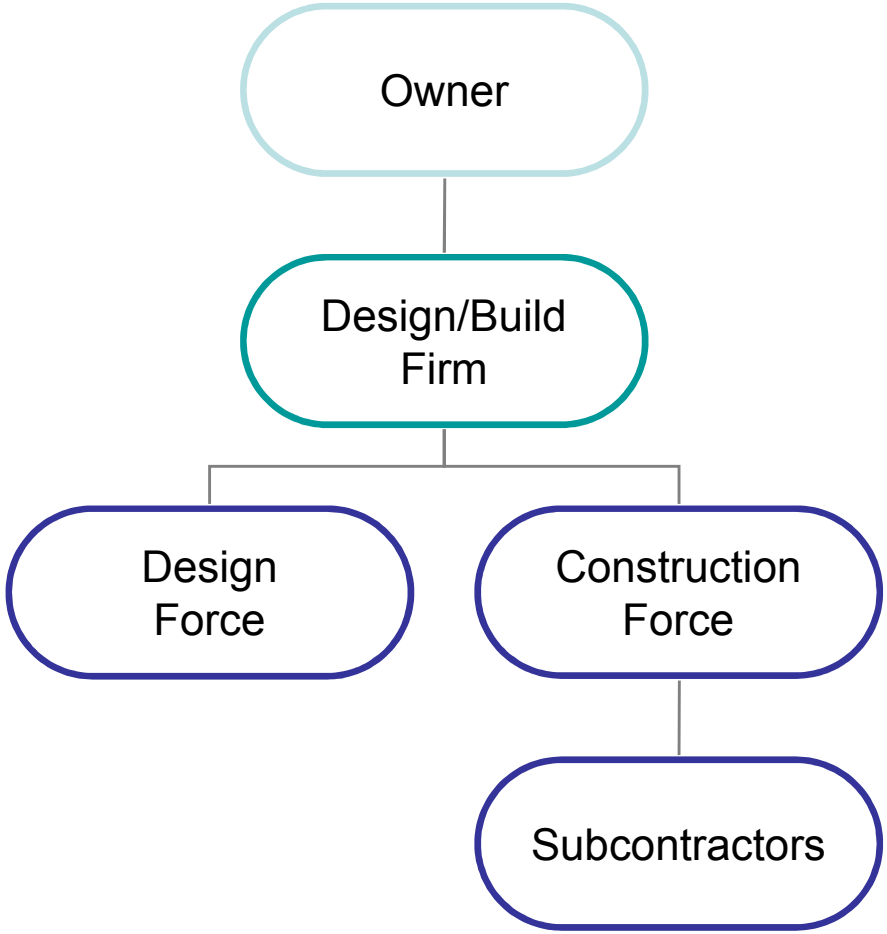


Construction Organizations

General Contractor

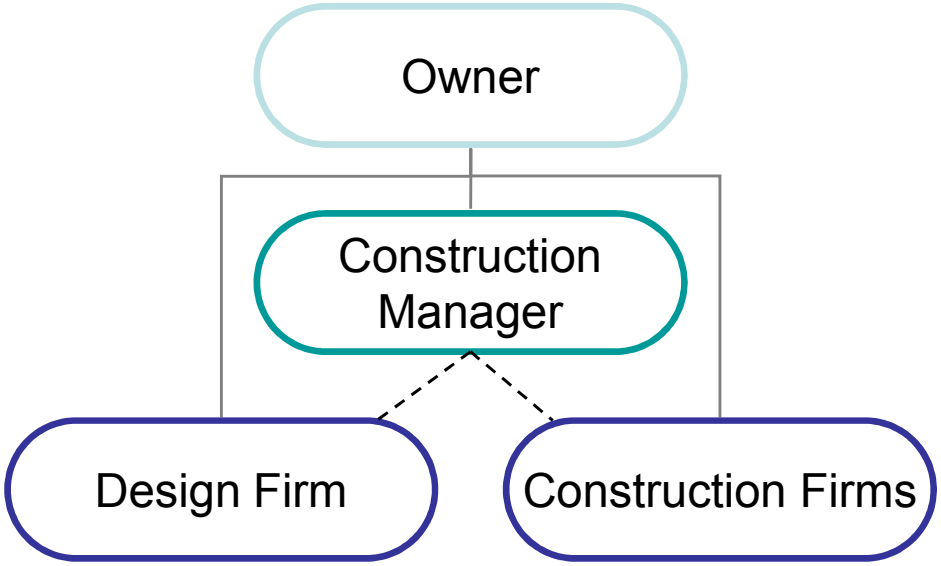


Design/Build



Construction Organizations

Construction Management



Construction Contracts

- Method of award
  - Formally advertised contracts
  - Negotiated contracts
- Method of pricing
  - Fixed-price
    - Lump sum contract
    - Unit price contract
  - Cost-plus
    - Cost plus percentage of cost
    - Cost plus fixed fee
    - Cost plus fixed fee with a guaranteed maximum cost
    - Cost plus incentive fee

Contract Documents

- General conditions
  - Defines responsibilities and rights
- Supplementary conditions
  - Types:
    - Modification of general conditions
    - Additional information beyond general conditions Plans
- Technical Specifications
- Drawings

Contract Documents : What You Might See

- Standard Specifications
  - General conditions
  - Technical specifications
- Contract Provisions
  - Bid proposal forms and regulations
  - Required contract provisions (bond, DBE, etc.)
  - Amendments to the standard specifications
  - Special provisions
  - Wage rate documentation
- Plans
  - Project drawings
  - Standard plans

Standard Specifications

- Construction Specifications Institute
  - MasterFormat 2004 Edition
    - 50 Divisions of construction information
    - Specifications-writing standard for most construction

MasterFormat 2004

<u>Example</u>

32 12 16.13 Plant-Mix Asphalt Paving

32	=	Level 1	=	Division 32: Exterior Improvements
12	=	Level 2	=	Flexible Paving
16	=	Level 3	=	Asphalt Paving
13	=	Level 4	=	Plant-Mix Asphalt Paving

Standard Specifications for DOTs

- Typically do not use MasterFormat 2004
- Generally use 9 Divisions:
  - General Requirements
  - Earthwork
  - Production from Quarry and Pit Sites and Stockpiling
  - Bases
  - Surface Treatments and Pavements
  - Structures
  - Drainage Structures, Storm Sewers, Water Mains, and Conduits
  - Miscellaneous Construction
  - Materials

http://www.wsdot.wa.gov/eesc/design/projectdev/gsppage1.htm

Unit Prices

- Standard Units
  - Defined in Standard Specifications

5-04.5 Payment

Payment will be made in accordance with Section 1-04.1, for each of the following bid items that are included in the proposal:

"HMA Cl. ___ PG ___", per ton.

"HMA for Approach Cl. ___ PG ___", per ton.

"HMA for Preleveling Cl. ___ PG ___", per ton.

"HMA for Pavement Repair Cl. ___ PG ___", per ton.

"Commercial HMA", per ton.

The unit contract price per ton for "HMA Cl. ___ PG ___", "HMA for Approach Cl. ___ PG ___", "HMA for Preleveling Cl. ___ PG ___", "HMA for Pavement Repair Cl. ___ PG ___", and "Commercial HMA" shall be full compensation for all costs incurred to carry out the requirements of Section 5-04 except for those costs included in other items which are included in this sub-section and which are included in the proposal.

Unit Bid Items

http://www.wsdot.wa.gov/biz/contaa/uba/bid.cfm

Some Extremely General Rules-of-Thumb

- Density
  - Gravel borrow, aggregate, soils: 1.85 tons/yd^3
  - HMA, PCC: 2.05 tons/yd^3
- Mobilization
  - 5 to 15% of construction cost
- Traffic control
  - 5 to 25% of construction cost
  - Urban freeway work costs more (up to 30%)
- Design and construction engineering
  - Usually not included in bid
  - Can be 5 to 15% of construction cost
- Clearing, grubbing, demolition
  - $5,000/acre

Some Extremely General Rules-of-Thumb

- Right-of-way
  - Cost is per square foot ($20 to $50/ft^2 in urban areas)
  - Administration cost for each take
  - Relocation costs
- Detention and water treatment
  - $6/ft^2 of roadway surface
  - $10/ft^2 of roadway surface in pond area is purchased
- Environmental permits and mitigation
  - $150,000/acre or $31/yd^2
- Temporary water pollution and erosion control
  - 2% of construction cost
- Traffic signals
  - Variable…but basic ones can cost in the neighborhood of $200,000
- Survey
  - Construction survey: 1.5% of construction costs
  - Design survey: 1.5% of construction costs

Quality Control

<u>Definition</u>

Actions and considerations necessary to assess production and construction processes so as to control the level of quality being produced in the end product.

- Measuring output
- Using results to adjust process

Acceptance

<u>Definition</u>

Formal procedure used to decide whether work should be accepted, rejected, or accepted at a reduced payment.

- Three forms:
  - Accept with no inspection
  - 100 percent inspection
  - Acceptance sampling

QC Density Testing

Acceptance Density Testing

Truck Bed Sampling

Lakeside Industries, Night Paving

Truck Bed Sampling

Dividing sample for an ignition oven asphalt content test

Truck Bed Sampling – Automatic

PCC Smoothness Testing

Methods of Price Adjustment: HMA

- Statistical evaluation
  - Jobs over 2,500 tons of HMA
  - Most strict tolerance limits
- Nonstatistical evaluation
  - Smaller jobs (City, County)
  - Less strict tolerance limits
- Commercial evaluation
  - Minor areas (e.g. sidewalks, paths, gores)
  - Least strict tolerance limits

Statistical Evaluation

- Calculate a "pay factor" (PF)
  - For each item measured
- Calculate a "composite pay factor" (CPF)
  - Each item measured is weighted by "f" factor

$$CPF = \frac{f_1\left(\overline{PF_1}\right) + f_2\left(\overline{PF_2}\right) + \ldots + f_i\left(\overline{PF_i}\right)}{\sum f_i}$$

Price Adjustments: HMA

- Mixture
  - Gradation
  - Asphalt content
  - Laboratory air voids

$$JMCIF = 0.60(CPF - 1.00)$$

- Compaction
  - Density

$$CIPAF = 0.40(CPF - 1.00)$$

- Others
  - Cyclic density (temperature differentials)
  - Smoothness

$$\text{Total Pay} = \text{Tons} \times \text{Unit Price} \times \text{Pay Adjustment Factor}$$

Methods of Price Adjustment: PCC

- Statistical evaluation
  - WSDOT jobs over 1,500 yd^3
  - Most strict tolerance limits
- Nonstatistical evaluation
  - Smaller jobs
  - All contracts not administered by WSDOT
  - Less strict tolerance limits

Statistical Evaluation

- Calculate a "pay factor" (PF)
  - For each item measured
- Calculate a "composite pay factor" (CPF)
  - Each item measured is weighted by "f" factor

$$CPF = \frac{f_1\left(\overline{PF_1}\right) + f_2\left(\overline{PF_2}\right) + \ldots + f_i\left(\overline{PF_i}\right)}{\sum f_i}$$

Price Adjustments: PCC

- Mixture
  - 28-day compressive strength (mean of 5 sets of 28-day compressive strength cylinders or 3,000 psi, whichever is higher)
  - Air content (3.0 to 7.0%)
- In-place
  - Thickness
  - Smoothness

$$\text{Total Pay} = \text{Tons} \times \text{Unit Price} \times \text{Pay Adjustment Factor}$$

HMA Demonstration

- Hot Mix Database
  - ????
- HMA View
  - http://hmaview.ce.washington.edu/wsdot
  - http://hmaview.ce.washington.edu/mdsha

Engineer's Estimate Exercise

- Repaving my street in Ballard
  - Street is 500 ft long, 40 ft wide
  - Pavement is PCC, 6 inches thick
  - Replace with PCC, 8 inches thick
  - Replace curb and gutter
  - No storm sewer system
  - There are gas and sewer utilities under the pavement (deep enough that you do not have to relocate them)

Primary References

- Nunnally, S.W. (2001). *Construction Methods and Management*. 5th edition. Prentice Hall, Upper Saddle River, NJ.

- Construction Specifications Institute (CSI). (2006). CSI website. http://www.csinet.org

- Washington State Department of Transportation (WSDOT). (2006). Unit Bid History website. http://www.wsdot.wa.gov/biz/contaa/uba/bid.cfm