Introduction to Construction Process and Cost Estimating for a Facility

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1. A BRIEF SUMMARY

Construction process is a series of tasks for the implementation of a facility. This process is closely related to the design and project management. Project design and management are activities for the construction process to take place. Design is an idea of description for the facility, usually represented by report, specifications, detailed plans, and possible revisions during the construction process. Project management is a process of activities that control the time schedule as well as the distribution of labors, materials, tools, and equipment for the construction process (CMU, Reference 1). It is important for various types of contractors to know the details of the construction process in order to better design or manage a construction project. Cost estimating for a project are also associated with the construction process, and in turn, depending on the design and management of the project. Plans reading and value engineering are important elements for cost estimating of the project.

The purpose of this paper is to identify the components of construction process for a more general case. It selects the construction of a building, such as a house or office to be an example. The design and project management portion are included in this process and will not be discussed in details. This paper also discusses methods for estimating the cost of a construction project. The following information may be useful for various contractors to better understand a construction project. And therefore, the contractors can better respond to a "request for bidding," i.e., a request for quotation, proposal, or qualification.

2. THE PROCESS AND COMPONENTS OF A CONSTRUCTION PROJECT

(1) The Design Documents

In the case of a firm being selected to design a construction project following a "Request for Qualification," its engineers or architects are responsible for the preparation of a project manual and the construction plans." In some cases, however, the constructors are required to submit a proposal for a construction project. The construction may not require engineering or architectural documents. In this connection, the constructors have to submit a proposal of descriptions or specifications in connection with their prices of bidding.

A design manual usually consists of three portions. One is to show the compliance of the bidder to the requirements of the biding agency, which may include contract conditions, general specifications, and bond and insurance certificates. Secondly, the manual has to

present technical descriptions and specifications that shall comply with a standard or the required characteristics of each item to be constructed. Finally, it may have to discuss its efforts to recruit certified minority vendors during the project application stage, if the bidding agency has a minority vendor procurement program.

The construction plans are usually associated with the design manual. The plans generally begin with site development drawings, which show the location of the project, its plat and zoning, and the existing buildings, followed by a set of plans including grading, drainage plan, erosion and sedimentation control, tree and environmental protection, traffic controls, and the demolition plan. For a building construction, the second set of plans start with foundations, structural diagram, structure details, and MPE (mechanical, plumbing, and electrical) plans. These plans may be preliminary and being finalized with the permitting process. When a permit is approved, the design manual and construction plans are distributed to related personnel and service providers for the next stage of construction.

(2) Value Engineering

For the planning and management of a construction project, "value engineering" should be considered and applied to the design and construction (B. J. Jackson, Reference 2). For the designer, value engineering is to choose an application that shall minimize the cost of construction subject to the requirement of project values. Values refer to the compliance of standards, specifications, and schedule of the construction. For the constructor, value engineering is to choose a plan and schedule for project management. This management process shall achieve the best project value with a minimum cost. The cost is associated with the pay application for each construction item. The project value, again, is to comply with the construction schedule, standards, and specification.

(3) Permitting Process

Permit for construction from an authority (e.g., building inspection department of a city) is necessary for most constructions. The designer should submit sets of construction plans for review. The authority will review the application, starting with drawing scale and zoning check, then the plat, site development drawings, and all other construction plans. A general permit is issued when all the plans are approved. Construction can begin following the approval. On-site inspections shall proceed during and after each process of construction. Construction plans may be revised. When construction is complete and all inspections are passed, a written approval or Certificate of Occupancy (CO) shall be issued.

(3) Preparations for Construction

Some tasks are necessary before the construction of a new facility begins. These tasks are listed as, but not limited to, the following:

- Obtain building and site development permits from the authority.
- Prepare plans of scheduling and project management.

- Establish routes of transportation around the construction site.
- Conduct site clearing to remove subjects of obstruction.
- Demolish and dispose unused structures; clear debris and trash.
- Develop tree protection plan and erosion and sedimentation control measures.
- Bring temporary electricity to site; also natural gas to site if necessary.
- Set up temporary toilet and dumpster.
- Construct temporary sites of disposal.
- Identify existing utility lines.

(4) Stakes Setting for Structure Site

Engineering survey is deemed necessary for a new construction. Surveying shall be conducted to stake out reference points and markers that can guide the construction of structures. Markers are generally staked out according to a coordinate system for the construction.

(5) Earthwork Excavation

Excavation is an earthmoving site work. Earthmoving work may include cut, fill, piling, and scraping. The excavation is mainly for grading, leveling, and layout of locations. It requires various types of earthmoving machinery to be used for this task. Soil samples can be obtained for testing at this stage.

(6) Footings and Foundation

Nowadays footings are an integrated part of a foundation, which supports a structure or building. Footings are formed in trenches being dug along the perimeters and the structural loading areas of the building. The lower portions of trenches are filled in with concrete and rebar to form footings. The bottom of the footings shall reach rocks or the undisturbed soil (R. Binsacca, Reference 3). The depth of footings must extend to about a foot or more below the frost line and shall avoid reaching the water table.

When footings are finished, foundation walls shall be formed and mounted to footings. In turn, the building slabs are tied to the walls. Below the slabs, it is the large gravels or other solid materials. The foundation for a building is then an integrated, solid body that can avoid settlement or movement.

A perimeter drainage system for the foundation shall be established. It usually takes perforated plastic pipes, set on top of the footings, for the water drain from the pile of gravels. Pipes, however, shall be protected from clogging by setting a layer of gravel and a strong, meshed fabric over the top of the pipes.

(7) Building Framing

Framing is a major part of the structure for a building. The walls along the perimeters of the building are composed of 2” x 4” platform framing. These 2” x 4” studs are either wood or

metal corresponding to domestic and commercial uses. The platforms are nailed to the sill plates, which are bolted to the foundation wall. They are also tied to each other at the both sides of the platform. Sill sealer shall be placed between sill plate and the top of the foundation wall for a tight connection. Wood sill plate has to be treated with a rot-resistant preservative at the lumber mill in order to prevent the infiltration of the moisture.

Windows and doors can be framed along the perimeters of walls at this time. A thicker wall may be formed by using 2" x 6" studs. This shall accommodate the needs for additional insulation and other special requirements.

On top of the building it's beams and trusses, which support the roof. This structure shall be firmly tied to the wall framing. Roof of specific types can be installed following a rough MPE job. Framing structures and roofing are subject to structural inspections.

(8) Rough Mechanical, Plumbing, and Electrical Work (MPE Work)

Following wall framing, some MPE works have to be completed before the walls and ground are covered. In reality, the plumbing drain pipes, some of the water tubes, and even part of the electrical wires are located under the foundation slabs.

In general, most utilities enter a building at the same area. Some of their pipes, tubes, and electrical wires are usually hided or going through the platform walls. The metal ducts of air conditioning (AC), the ventilations of AC and plumbing equipment, and some of the electrical tasks are generally associated with the framing and trusses work at the top of the building. These jobs constitute the rough portion of the MPE work. This rough work is also subject to initial MPE inspections.

(9) Insulation and Dry Walls

Sheetrock has been mostly used to cover the inside walls of a building. It's called a drywall, which covers rough framing, MEP parts, and the insulation. The sheetrock panels are nailed or screwed into the narrow studs. Sometimes the metal clips are used to secure the edges of two connected panels. Mudding, tapping, and texturing are also important tasks for drywall. These tasks fasten and smooth the joints and corners of the sheetrock panels. For insulation, rolled packs of fiber glass of 15"-wide are usually placed between any two studs.

There are various types of insulation materials, including loose-fill coverage, expanded foam, and 4' x 8' panels. The panels can be attached to the outside surface of studs next to the siding. Insulation of Loose-fill type or fiber glass pack is often placed on the top of ceiling panels. Ceiling panels have different types such as sheetrock, light-weight particle board, and panels of suspended ceilings.

Pre-made windows and doors are generally installed at this stage. There are schedules for windows and doors on the construction plans, which present the specifications of different

groups of these items. Except being used as an access to and from the building, windows and doors serve as devices for transferring heat, moisture, and airflow. For safety concern, each room in a building must have a window to be accessed to the outside.

(10) Exterior and Interior Finishes

This stage approaches the end of the construction process but it requires more time for project management. The ending process is tedious but it determines the appearance of a building.

One task is to finish the roofing work. Roof has different types. In general, all roofs, whether it's slopped or flat, require a good, strong base structure for support. A layer of water proof paper can be attached to the structure or baseboard. Roof materials are then applied. Some gutters and downspout around the roof edges are also necessary. For a slopped roof, there are some critical areas such as roof valleys, roof edges, and places around chimneys and vent pipes, the roof flashing of sheet metals should be installed.

Sidings are another protective element. It is also a primary decorative feature for building structures. Siding can be many types, such as brick, masonry, vinyl, stucco, and concrete strips. For siding installations, it should pay attention to the coverage of adjacent joints or small cracks in order to prevent moisture from entering the siding walls.

Other exterior finishes include parking, driveways, walkways, fencing, landscaping, building trim and lighting, water and electricity accesses, and the drainage and its facilities.

Interior finishes refer to many tasks. Painting of walls, ceilings, and trims is a necessity, and a delicate job. Installations of cabinets, counter tops, and storage spaces are generally necessary for buildings. Then there is flooring work, which may vary in design from room to room. The most important task of interior finishes is to complete MPE work. This task involves the installations of MPE equipment such as air condition cooling and heating devices, ventilation system, plumbing equipment, and the lights and receptacles. This task requires labors with special skills or licenses.

(11) Cleaning and Final Inspection

The last process of building construction is the cleaning of construction sites, both the inside and outside areas. Then the final inspection and approval of the construction is required. This may consist of a general review of site and structures, safety issues, and specific MPE work inspections. A written approval or Certificate of Occupancy shall be issued that is the evidence of the final approval.

3. COST ESTIMAING FOR CONSTRUCTION

(1) A General Method for Estimating Cost

One can follow a procedure specified below for estimating the cost of a construction item:

- One factor on cost for a construction item is the type of materials, whether it is wood, steel, masonry, concrete, or composite materials.
- Unit cost for the item or material can be estimated from various sources. This cost may depend on the quality of material. Quality refers to plan specifications and the type of material. Geographic area modification and cost historic indices must also be considered.
- The dimension of the item has to be determined from the plan reading.
- The total quantity of materials can be evaluated from the dimension and the characteristics of the specific material.
- The total cost for the item is then the unit cost multiplying by the total quantity of the item.

(2) A Simple Example of Cost Estimation

Suppose there is a patio to be constructed. The patio area is framed and its base has been formed. Rebar has been laid out inside the patio area. Specific type of concrete mix is to be poured into the framed space. The essential cost of materials for the patio is the price of concrete and cements to be used. Following paragraphs provides information for the estimation of this cost:

- The dimensions of concrete portion for the patio is specified to be 18' wide, 16' long, and 6" deep. The total volume of concrete needed is then, 18 x 16 x 0.5 = 144 cubic feet, which is equivalent to about 5.4 cubic yard (144/27).
- Additional cement-based product is necessary for surfacing the patio. This dimension of surface layer is assumed to be about 0.50 cubic yard.
- This paper assumes that the local, unit prices of mixed concrete is $100 per cubic yard, including material price, delivery fee, and pouring charge. The unit price for cement is estimated to be $150 per cubic yard.
- It is further assumed that the qualities of concrete and cement materials conform with the requirements of specifications as described in the construction plan.
- The total cost for the concrete and cement materials can then be calculated as:
  Estimated material cost = 100 x 5.4 + 150 x 0.50 = $615.00

(3) Estimation of Labor Cost

The above example does not provide information on the costs of other materials and labor for the construction of a patio. The labor cost for each person is generally determined by the unit labor rate of this person (dollar per hour), and the total number of hours on the job. Contractor may use information below to estimate labor cost for a specific job.

- The unit labor rate can be estimated by two ways. Labor for each profession has a prevailing rate, which may depend on the geographic areas. There is a unit labor rate for a specific type of job or project. This information is also available (W.P. Jackson, Reference 4 and S. Siddens, Reference 5).
- The total time needed for a specific job depends on the project schedule and the work

experience on the similar project. There must be a time schedule for each construction project. This information can also be obtained from available references such as those specified above.
- The overhead cost and the desired profit for a project are not necessarily included in the labor cost for an easier estimation.

(4) Overhead Costs

The overhead costs for a project generally include these items listed below:

- Costs of insurance, bonds, and work comp.
- Transportation-related costs for conducting the project.
- Equipment rental costs and the depreciations of the owned equipment.
- Cost of preparations for bidding, including bid, proposal, or qualification.
- Cost of office use and the expenses for utilities.

Also, the expected profit from the project shall be considered as a percentage of the total project valuation.

(5) Requirements of Skills for Cost Estimation

Contractors should have specific skills for cost estimation of a project or a specific construction. This may include:

- Understand the process of construction and the details of each process so that the required labors and materials for each specific job can be quantified.
- Be able to read construction plans so that the project items and the dimensions and specifications of each item can be identified.
- Be able to develop project schedule and project management plan for the construction so that the project cost can be better controlled.

4. CONCLUSIONS

This paper discusses construction process and cost estimation, and refers to project schedule and management. The construction process has a series of tasks, which are in accordance with the descriptions and specifications of the construction plans. Cost estimating for a construction depend on the dimensions and specifications of the construction item, and the time schedule and unit labor rate for this item. Project management controls construction specifications and project schedule, and takes into consideration of the value engineering. Value engineering is to find the most cost effective solution during project design or the management stage but at the same time the specification and time schedule for the construction can be maintained.

It is necessary for a designer or a contractor to know the construction process and cost estimation in order to respond to a bid and to manage the project when the project is secured. Also, for a contractor, the skill in “plan reading” is essential for cost estimating of a construction.

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