

Building Construction Process and Cost Optimization

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BUILDING CONSTRUCTION PROCESS AND COST OPTIMIZATION

I. INTRODUCTION

Building construction process is a series of tasks for the implementation of a building. The tasks consist of design, project management, and the building process. Design is a description of ideas for the building, which can be presented as report, specifications, detailed plans, and possible revisions during the construction process. Project management is a process of activities that controls the time schedule as well as the distribution of labor, materials, tools, and equipment for the construction process (CMU, Reference 1). The building process will be described in detail in the following sections. Permitting and inspections are associated with each element of the construction process. Cost estimates for a project are also associated with the construction process. Plans reading and value engineering are important elements for the cost estimates.

It is important for Asian contractors to know the details of the construction process in order to perform the design and management for a construction project. Contractors are those businesses or individuals who bid and obtain a contract to perform work for one or more projects (ACA, Reference 2). In this study, contractors refer to engineers, architects, constructors, and any other construction-related personnel or businesses.

The purpose of this paper is to identify and describe the elements of the construction process for the implementation of a building. This paper also discusses methods and optimization for Asian contractors in estimating the cost of a construction project. The following information may be useful for the Asian contractors to better understand the construction process, and therefore, the contractors can better respond to project bidding such as requests for quotation, proposal or qualification (ACA, Reference 3).

II. THE ELEMENTS AND PROCESS OF BUILDING CONSTRUCTION

1. Design Documents

In response to the “request for qualification,” the engineers or architects of a firm are responsible for the preparation of design manual and the construction plans. A design manual usually consists of three portions. One is to show the compliance of the bidder to the requirements of the bidding 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 will have to discuss its efforts to recruit certified Asian contractors during the project application stage, if the bidding agency has a minority contractor procurement program. The construction plans are usually associated with the design manual.

In general, the construction plans begin with site development drawings. The site plans show the project location, the plat and zoning, and the existing buildings, followed by a set of plans.

The plans include grading plan, drainage system, erosion and sedimentation control, tree and environmental protection, traffic controls, and the demolition plan. The set of plans starts with foundations, structural diagram, structure details, and MEP (mechanical, electrical, and plumbing) systems. These plans may be preliminary which are being finalized with the permitting process. When a permit is approved, the design report and construction plans are distributed to related personnel and service providers for the next stage of construction.

2. Value Engineering

Value engineering is an optimization method. It should be considered and applied to the design and construction processes for building construction (Jackson, Reference 4). 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 requirements of construction plans such as the planned standards, specifications, and schedule of the construction. For the constructor, value engineering is to choose a plan and schedule for managing the project. And this management process shall achieve the best project value. The project cost is associated with the pay application for each construction item. The project value, again, is to comply with the planned schedule, standards, and specifications.

3. Permitting Process

Permitting for construction by the authority is necessary for most of building constructions. The designer submits construction plans for review. The authority shall review the application starting with the drawing scale and zoning check; followed by the drawings of plat, site development drawing, and all other construction plans. A general permit is issued when all the plans are approved. Construction may 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 the associated inspections are passed, a written approval or Certificate of Occupancy (CO) shall be issued.

4. Preparations for Construction

Some tasks are necessary before the building construction begins. These tasks are listed as, but not limited to the following:

- Obtain site development and building permits from the authority.
- Prepare scheduling and project management plans.
- Establish routes of transportation at the construction site.
- Conduct site clearing to remove subjects of obstruction.
- Demolish and dispose unused structures, clear debris and trash.
- Develop tree protection plans, and erosion and sedimentation control measures.
- Bring temporary electricity to site; also, natural gas if necessary.
- Set up onsite toilet and dumpster.
- Construct temporary sites for disposal.

- Identify existing utility lines.

5. 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 staked out in accordance with a coordinate system.

6. Earthwork and Excavation

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

7. Footings and Foundation

Nowadays footings are the integrated part of a foundation, which supports a structure or the 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 (Binsacca, Reference 5). The depth of footings must extend to about one 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.

8. 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 on both sides of the platform. Sill sealer shall be placed between sill plate and at the top of the foundation wall for a tight connection. Wood sill plate must 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, there are 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.

9. Rough Mechanical, Electrical Work, and Plumbing Work (MEP Work)

Following wall framing, some MEP works (ACA, Reference 6) have to be completed before the walls and ground are covered. In reality, the plumbing drainpipes, 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 in the same area. Some of their pipes, tubes, and electrical wires are usually hidden or going through the platform walls. The metal ducts of air conditioning (AC), the ventilation 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 a rough portion of the MEP work. This rough work is also subject to initial MEP inspections.

10. Insulation and Dry Walls

Sheetrock has been mostly used to cover the inside walls of a building. It's named the drywall, which covers rough framing, MEP parts, and the insulations. 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 15"-wide glass 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 sheet rocks, light-weight particle boards, and panels of suspended ceilings.

Pre-made windows and doors are generally installed at this stage. There are schedules for windows and doors in the construction plans, which present the specifications of different groups of these items. Except being used as access to and from the building, windows and doors serve as devices for transferring heat, moisture, and airflow. For safety reasons, each room in a building must have a window to be accessed to the outside.

11. Exterior and Interior Finishes

This stage of work approaches the end of the construction process, but it requires more time for project management. One task is to finish the roofing work. In general, all roofs, whether it's slopped or flat, require a good and strong base structure for support. A layer of waterproof paper can be attached to the structure or baseboard. Roof materials are then applied. Some gutters and down spouts around the roof edges are also necessary. For a slopped roof, there are some critical places such as roof valleys, roof edges, and area around chimneys and vent pipes. The roof flashing of sheet metals should be installed.

Sidings is another protective element. It is also a primary decorative feature for building structures. Siding has 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 to prevent moisture from entering the siding walls. Other exterior finishes include parking, driveways, walkways, fencing, landscaping, building trims and lighting, water and electricity accesses, and the drainage and its facilities.

Interior finishes refer to many tasks. The painting of walls, ceilings, and trims is a necessary and delicate job. Installations of cabinets, counter tops, and storage spaces are generally required for buildings. Then there is flooring work, which can vary in design from room to room. The most important task of interior finishing is the MEP work. This task involves the installation of MEP equipment such as air conditioning and heating devices, ventilation system, plumbing equipment, and lighting and receptacles. This task requires labors with special skills and licenses.

12. Cleaning and Final Inspection

The last process for building construction is the cleaning of construction sites, both inside and outside. Then the final inspection and approval is required. This may consist of a general assessment of site and structures, safety issues review, and specific MPE work inspections. A written acceptance or certificate of occupancy (CO) shall be issued to identify the final approval.

III. COST OPTIMIZATION FOR BUILDING CONSTRUCTION

The cost for building construction depends on its expense of labor, materials, and the overhead items.

1. Cost of Labor

The total labor cost for a worker in building construction is his/her unit labor rate, dollar per hour, times the total number of hours on the job. The unit labor rate can be estimated in two ways. Labor for each profession has a prevailing rate, which may vary depending on the geographic areas. There is also information on the unit labor rate for specific type of job or project. This information is available and published in two references (Siddens, Reference 7).

The total time needed for a specific job depends on the project schedule and the work experience on similar projects. The time schedule is also available as specified in the above-listed references (References 4 & 7).

1. Cost of Materials

The cost of an item for building construction depends on the type and quality of its material. There are different types of materials such as wood, steel, masonry, concrete, or composite material. The unit cost for each type of material can be estimated from various sources (Reference 4). The total cost for this material is the unit cost multiplying by the total quantity used for the construction. The total quantity can be evaluated from plan reading. The plan reading provides information about the dimensions and characteristics of the specific material.

The quality of materials is defined by plan specifications. Each item of material used for building construction should comply with the requirements specified in the construction plan. While the overall cost of construction is minimized, the quality of the building resulting from the construction must be maintained.

2. Overhead Cost

The overhead costs for building construction generally include these items as listed below:

- (1) Costs of insurance, bonds, and work comp.
- (2) Transportation-related costs for conducting the project.
- (3) Rental equipment and the depreciation of the equipment owned.
- (4) Cost of preparations for bidding, including bid, proposal, or qualification.
- (5) Cost of office use and the expenses for utilities.

3. Cost Optimization

Optimization is to achieve a project in a best or most effective way. As to the optimization for building construction, it may be minimizing the cost of construction using available resources, while the project is finished on time (Mulay, etc., Reference 8). Quantitatively, the optimization is to minimize the overall cost of the project, subject to the requirements of the construction plan, such as the time schedule, quality of the product, and limitation of resources.

There are different techniques for optimization in building construction. The main factors that impact optimization are procurement process, project management, and the techniques used for construction. In this regard, the contractor must have sufficient knowledge of cost estimation for a construction project.

Requirements of Skills for Cost Estimation

As a construction worker, Asian contractors should have specific skills in cost estimation. This may include:

- (1) Understand the process of construction and the details of each process so that the required labor and materials for each specific job can be quantified.
- (2) Be able to read construction plans so that the project items and their dimensions and specifications can be identified.
- (3) Be able to develop project schedule and project management plan for the construction so that the project cost can be optimized.

III. CONCLUSION

This paper describes the process for building construction, and the associated cost estimation and optimization. The construction process has a series of tasks, including engineering design, site development, and the building process. In general, the building process consists of permitting, site preparation, foundation setting, framing work, siding and roofing, and final finishes. Permitting and inspections are associated with the construction process at different stages.

Cost estimates are based on various facts, such as the time schedule, labor rate, and the dimensions and specifications for each of the construction items. Procurement process and project management are the important factors in determining the cost for building process. Value engineering should be taken into consideration for each phase of construction. Value engineering refers to optimization method that it can be quantified (Gass, Reference 9). Optimization for building construction is to minimize the cost for each item of construction, subject to the requirements of the construction plans.

This paper is designated to provide technical information to Asian contractors. It is important that a contractor in building construction should also be skilled in plan reading, cost estimating, and project management.

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