AC 2012-3960: SCOPE OF PRECONSTRUCTION SERVICES IN GREEN BUILDING PROJECTS

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Scope of Preconstruction Services in Green Building Projects

Abstract

The building construction industry is continuously experiencing significant changes in practice because of the rapid development of new technologies, methods and materials. The industry stakeholders, including designers, engineers and contractors, are often forced to develop and implement creative and non-traditional strategies to keep up with the new trends while staying efficient, effective and competitive. Sustainability and green building practices are good examples of such new trends which became focal points building construction projects in the last decade. In this transition, construction contractors expanded their capabilities beyond traditional project delivery methods. The majority of top green building contractors in the United States maintain significant experience and expertise in Construction Management at Risk delivery method. This type of delivery places large emphasis on preconstruction making it a vital process in green building projects. In addition, sustainability and green building trends added different attributes to the preconstruction process beyond the traditional services. This paper aims to explore the differentiating characteristics of preconstruction services in green building projects in comparison to the traditional project delivery. The paper highlights the new qualifications that are increasingly expected from construction companies during the green building projects' preconstruction process. The additional attributes and abilities that are expected from the contractors are summarized in the paper including the ability to analyze innovative technology scope, effective use of building information modeling related technologies, energy modeling analysis, fundamental knowledge of ecology, and building life cycle cost analysis. The discussions provided in this paper provide a structured framework to introduce the green preconstruction process in the classroom as well as a source for construction contractors to expand their services.

Introduction

The construction industry is continuously experiencing new technologies, methods and significant changes in practice. Construction companies need to put creative strategies in place in order to keep up with the new trends while staying efficient, effective and competitive. In the last few years, sustainability and green building practices became a focal point for construction industry. “One of the major trends for the near future construction works is that the owners will be in the search of construction companies that their service scope is beyond designing and building such as providing consulting in the areas of finance, facilities management, environment, legal, social, economic, political and cultural issues”¹. This statement is especially true since the demand for sustainable projects is growing, and owners expect more services from construction companies in respect to green projects.

In 2007, Engineering News Record Magazine initiated the publication of the top green contractors. The top 50 green contractors' revenue generated from registered green projects constituted 15.3% of their total construction revenue in 2006 ². The following year, the list was extended to the top 100 firms and the revenue generated from the registered projects constituted 20.1% of their total construction revenue ³. Despite the tumbling market conditions, the revenue
generated from the registered green projects constituted 26.2% of the total construction revenue of the top 100 green contractors in 2008 which corresponds to 70% increase in one year. The top 400 contractors' total revenue grew only 11.2% in the same year.

The increasing presence of the green building projects was also reflected in the project delivery method choices for such projects. Kibert (2005) groups the contemporary construction delivery methods used in the United States as Design-Bid-Build, Construction Management at Risk (CM at Risk) and Design-Build. The contractual relationships related to these different delivery methods directly affect the stage of involvement for construction contractors. There is no doubt that early contractor involvement in the decision making process provides valuable contributions to the project and may significantly change the outcomes including cost, quality and sustainability goals. The United States Green Building Council’s Leadership in Energy and Environmental Design (LEED) Rating System application process is a good example of such early collaboration. The current LEED Rating System for New Construction and Majors Renovations include seven major topics including Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority. In traditional design-bid-build projects, the contractors are typically involved in the process after the design is substantially completed where the performance of the contractor towards the LEED certification process is primarily limited to Materials and Resources and some parts of Indoor Environmental Quality topics. On the other hand, Design-Build and CM at Risk delivery methods may include the contractor in the decision making process earlier compared to the design-bid-build approach and may result in providing opportunities in other LEED topical areas.

The companies, who specialize in design-build and CM at Risk delivery methods, also specialize in preconstruction services. The reason for it is that the contractors are a part of the project in the design stage to integrate their construction expertise into the design development. In certain cases, they prepare guaranteed maximum price (GMP) for project owners usually based on 75 to 80% complete construction documents. The GMP brings substantial risk to contractors since they promise a cap price to project owners. The ability to take such risks is possible by being able to conduct and perform well in preconstruction. This is the stage where a contractor can accomplish a risk management plan for the entire construction process. Part of the top 100 green contractors' success can be attributed to their preconstruction expertise which comes from their CM at Risk project delivery expertise (Table 1). Green building process may significantly benefit from a collaborative project delivery approach which emphasizes the early teaming of project stakeholders (owner, contractor, designer).

The evolving project conditions, delivery approaches, and emphasis on preconstruction services also create a challenge from an educational perspective where the green building practices are typically covered in specialized courses with a focus on sustainability. Nevertheless, it is crucial to bring these into construction management courses in order to compare with traditional construction management processes. This paper aims to explore the differentiating characteristics of preconstruction services in green building projects in comparison to the traditional project delivery. The paper highlights the new qualifications that are increasingly expected from construction companies during the green building projects' preconstruction process. The additional attributes and abilities that are expected from the contractors are summarized in the
paper including the ability to analyze innovative technology scope, effective use of building information modeling related technologies, energy modeling analysis, fundamental knowledge of ecology, and building life cycle cost analysis. The discussions provided in this paper provide a structured framework to introduce the green preconstruction process in the classroom as well as a source for construction contractors to expand their services.

**Project Delivery Methods of Top Green Contractors**

When early collaboration between contractors and designers (engineers and architects) are discussed in the classroom, the conversation usually gravitates toward Design-Build because of the apparent contractual characteristics. It would appear that Design-Build delivery method would provide a more dominant market presence for green building projects compared to other methods. However, the construction industry trend in the last few years shows a different trend. Table 1 presents a summary of the project delivery preferences and revenues of the top 20 green contractors in 2009.

**Table 1. 2009 Top 20 Green Contractor Delivery Methods and Revenues**

<table>
<thead>
<tr>
<th>Top 20 Green Contractors based on Registered Green Projects</th>
<th>Total Construction Revenue ($M)</th>
<th>CM at Risk Revenue ($M)</th>
<th>Design-Build Revenue ($M)</th>
<th>Major Delivery Method Practiced (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Turner Construction</td>
<td>7,878.9</td>
<td>7,047.4</td>
<td>831.5</td>
<td>CM at Risk (89.4%)</td>
</tr>
<tr>
<td>2. Perini Corp.</td>
<td>5,141.0</td>
<td>4,753.4</td>
<td>380.1</td>
<td>CM at Risk (92.5%)</td>
</tr>
<tr>
<td>3. Hensel Phelps Construction Co.</td>
<td>3,026.5</td>
<td>806.2</td>
<td>1,915.1</td>
<td>Design-Build (63.3%)</td>
</tr>
<tr>
<td>4. Clark Group</td>
<td>4,899.9</td>
<td>2,243.1</td>
<td>1,661.5</td>
<td>CM at Risk (45.8%)</td>
</tr>
<tr>
<td>5. Webcor Builders</td>
<td>803.9</td>
<td>-</td>
<td>180.4</td>
<td></td>
</tr>
<tr>
<td>6. Bovis Lend Lease</td>
<td>3,241.4</td>
<td>3,189.6</td>
<td>-</td>
<td>CM at Risk (98.4%)</td>
</tr>
<tr>
<td>7. Gilbane Building Co.</td>
<td>3,135.5</td>
<td>3,017.9</td>
<td>-</td>
<td>CM at Risk (96.2%)</td>
</tr>
<tr>
<td>8. PCL Construction Enterprise Inc.</td>
<td>5,428.6</td>
<td>1,898.0</td>
<td>508.0</td>
<td>CM at Risk (35.0%)</td>
</tr>
<tr>
<td>9. Balfour Beatty Construction</td>
<td>3,954.6</td>
<td>1,127.3</td>
<td>744.9</td>
<td>CM at Risk (28.5%)</td>
</tr>
<tr>
<td>10. The Whiting-Turner Contracting Co.</td>
<td>3,504.1</td>
<td>2,390.9</td>
<td>302.3</td>
<td>CM at Risk (68.2%)</td>
</tr>
<tr>
<td>11. Mortensen Construction</td>
<td>2,387.9</td>
<td>1,224.6</td>
<td>745.6</td>
<td>CM at Risk (51.3%)</td>
</tr>
<tr>
<td>12. Skanska USA, Inc.</td>
<td>5,695.8</td>
<td>2,707.5</td>
<td>796.5</td>
<td>CM at Risk (47.5%)</td>
</tr>
<tr>
<td>13. David E. Harvey Builders</td>
<td>755.0</td>
<td>575.0</td>
<td>-</td>
<td>CM at Risk (76.2%)</td>
</tr>
<tr>
<td>14. Haskell</td>
<td>452.0</td>
<td>-</td>
<td>374.6</td>
<td>Design-Build (82.9%)</td>
</tr>
<tr>
<td>15. Holder Construction Co.</td>
<td>1,253.0</td>
<td>1,224.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Hunt Construction Group Inc.</td>
<td>2,140.0</td>
<td>683.0</td>
<td>782.6</td>
<td>Design-Build (36.6%)</td>
</tr>
<tr>
<td>17. Structure Tone</td>
<td>2,731.7</td>
<td>2,510.0</td>
<td>98.4</td>
<td>CM at Risk (91.9%)</td>
</tr>
<tr>
<td>18. Swinerton Inc.</td>
<td>1,241.2</td>
<td>558.4</td>
<td>434.4</td>
<td>CM at Risk (45.0%)</td>
</tr>
<tr>
<td>19. Hoffman Corp.</td>
<td>963.4</td>
<td>902.2</td>
<td>-</td>
<td>CM at Risk (93.6%)</td>
</tr>
<tr>
<td>20. Austin Industries</td>
<td>1,857.6</td>
<td>1,101.2</td>
<td>116.1</td>
<td>CM at Risk (59.3%)</td>
</tr>
</tbody>
</table>
As illustrated in Table 1, the leading green contractors developed a particular expertise in CM at Risk delivery method. It is important to note that the total revenue generated by the top 20 green contractors constitutes 65% of the top 100 green contractor revenues. Experience in preconstruction services contributes to the success of CM at Risk contractors regardless of the project type. Although the scope of preconstruction services may be wider in green building projects, the fundamentals of the process do not change significantly. In this context, a comparative description of the traditional and green preconstruction scopes would provide practical tool to highlight the expected qualifications. This comparison would also provide a structured discussion in project management courses as the different stages of preconstruction services are introduced to the students.

Scope of Preconstruction Services in Traditional Building Projects

In simple terms, construction companies aim to assist the project team to obtain complete, constructible and value engineered construction documents by providing preconstruction services in the initial development and design stages. Effectively performed preconstruction services provide a smooth construction process as well as better management of project risks. Gould and Joyce (2003) describes a typical building design under four distinct stages including conceptual design (programming), schematic design, development of design, and development of construction documents. Contractors may provide preconstruction services in all of the design stages and there is typically a service fee charge between 2 to 5% of the project cost. It is important to note that this fee can easily be eroded if the risks are not effectively managed. These stages typically include the following tasks:

- **Conceptual design stage** includes the feasibility analysis and initial design tasks. Contractors start communicating with the project participants and become a part of the decision making process. Although the project information is limited, clear understanding of the project objectives is crucial for the successful development. In this stage, site and subsurface conditions are collected and a gross square footage of the project is established. A master schedule is developed for the design process which ends at the physical start of construction. A conceptual estimate (budget) is also developed along with subcontractor input and contingency considerations.

- **Schematic design stage** includes detailed site investigations with the analysis of environmental issues and existing structures that may affect the construction process, budget, and schedule. After the development of the means and methods related to the site logistics and relevant safety concerns, documentation of the project scope starts. In communication with the owner and designers, major building elements (foundations, structural systems, enclosure, mechanical-electrical-plumbing systems, etc.) are selected and their initial constructability analyses are performed. The master schedule is further developed with detailed preconstruction responsibilities of the project participants. Since the project scope is still being developed, the contractor's and specialty contractors' inputs are very valuable at this stage. The complete scope leads to an estimate with higher level of accuracy.

- **Design development stage** puts greater emphasis on the constructability issues. The design documents are reviewed by the construction team and, consequently, the cost estimate is updated. If a GMP is being provided, it is usually calculated and presented at this stage.
schedule is also updated as detailed design information become available. Value analysis is also performed at this stage, since detailed drawings are still in development and any changes can be incorporated into construction documents. The contribution of value analysis to the project can be significant. The close participation of the contractors and specialty contractors may also help with the timely actions for long lead items.

- **Construction documents** are developed in the last stage while most of the preconstruction services such as site logistics, safety planning, constructability analysis and scheduling are finalized.

Figure 1 shows a simplified illustration of preconstruction services involved in traditional building projects under the four design stages.

<table>
<thead>
<tr>
<th>CONCEPTUAL DESIGN</th>
<th>SCHEMATIC DESIGN</th>
<th>DESIGN DEVELOPMENT</th>
<th>CONSTRUCTION DOCUMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of site and subsurface conditions</td>
<td>Site investigations and analysis</td>
<td>Site logistics</td>
<td>Final site logistics plan</td>
</tr>
<tr>
<td>Development of master schedule</td>
<td>Site logistics</td>
<td>Safety</td>
<td>Detailed safety plan</td>
</tr>
<tr>
<td>Gross square footage and conceptual estimating</td>
<td>Initial constructability analysis for building elements and systems</td>
<td>Safety</td>
<td>Final constructability analysis</td>
</tr>
<tr>
<td>Further development of master schedule</td>
<td>Construction analysis</td>
<td>Value analysis</td>
<td>Final schedule development</td>
</tr>
<tr>
<td></td>
<td>Detailed schedule development</td>
<td>Development of cost estimate</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1.** Scope of Preconstruction Services in Traditional Building Projects
As illustrated in Figure 1, performing preconstruction services includes a variety of tasks that necessitates in depth knowledge and experience. Entry level project management or construction management courses may provide an appropriate platform to introduce the tasks in comparison to other delivery methods. However, actual performance of these tasks requires proper preparation of the students and may be more appropriate for a senior capstone course. For example, the estimating tasks would require students to be comfortable with performing plan reading, quantity take-off, labor/material pricing, construction cost database analysis, and contingency/profit calculation tasks and considerations. Similarly, selection of material and methods for the project require an understanding of each available method, related to construction cost, schedule and safety concerns.

It is extremely important to emphasize the communication aspect of preconstruction services while they are introduced in construction courses. Understanding of the roles and responsibilities of the project participants and proper communication formats would significantly affect the results of the preconstruction services. The criticality of clear and timely communications should be highlighted for each stage of the preconstruction services including written, oral, and/or graphical formats.

**Scope of Preconstruction Services in Green Building Projects**

In green building projects, stakeholders grow beyond the owner, designer, contractor, and specialty contractors to include representatives from the community and non-profit organizations. The communication between project participants is expected to be more intense and multi-dimensional. Preconstruction process plays a vital role in facilitating the interaction between participants while exploring effective ways to reach the project goals. The importance of clear and timely communication is raised to a higher level and may necessitate presentations to non-technical stakeholders.

The scope of preconstruction services in green building projects may be described as an enhanced version of the traditional building projects. The conceptual design, schematic design, design development, and construction document development stages encompass the green preconstruction services with additional tasks including:

- Consideration, analysis, and implementation of sustainable alternatives,
- Life cycle cost analysis in addition to the construction cost calculations, and,
- Early building commissioning planning and analysis.

These three tasks require additional expertise and experience within their individual domains. They may also directly affect the other preconstruction considerations including, site logistics, cost, and scheduling. The additional tasks may add to the design timeline but provide valuable perspectives and alternatives towards the project goals.

Based on the traditional preconstruction service framework and additional green tasks, Figure 2 presents the scope of the preconstruction for green building projects. Some of the green tasks in this illustration may be performed individually while others require consideration in conjunction with constructability and value analyses.
Review of site and subsurface conditions

Development of master schedule

Gross square footage and conceptual estimating

Site investigations and analysis

Site logistics

Safety

Initial constructability analysis for building elements and systems

Analysis of renewable sources and sustainable technologies

Commissioning planning

Further development of master schedule

Preliminary scope documentation and conceptual estimating

Development of cost estimate

Advanced schedule development

Detailed safety plan

Life cycle cost analysis

Detailed Commissioning planning

Additional tasks for green building project preconstruction services

**Figure 2.** Scope of Preconstruction Services in Green Building Projects
In Figure 2, the conceptual design stage includes a “charette”, or an initial planning session, to gather input from the various stakeholders. Considering the multitude of parties involved in the discussion, charettes may significantly benefit from a structured discussion format in which contractors may find an opportunity to present their expertise and establish leadership of the project.

In the schematic design stage, the analysis of renewable resources and sustainable technologies are included in addition to the commissioning analysis for the building. The renewable resource analysis include consideration of a wide range of options including availability and possible utilization of recycled materials, rapidly renewable materials, certified wood, regional materials, and building/material reuse. Additional sustainable technologies can also be considered at this stage such as renewable energy sources and integration. It is expected that green building projects include renewable energy technologies. Therefore, construction firms need to develop expertise in order to be able to integrate such technologies into buildings. Understanding the technical scope, handling estimating, scheduling, commissioning and testing aspects of these new technologies expand the scope of preconstruction services. These technologies include clean energy technologies such as solar, wind, hydrogen (fuel cells, biomass), bio-energy, geothermal and waste treatment to energy technologies for wide range of building wastes mainly in industrial buildings and hospitals\(^\text{10}\). Ability to analyze innovative technology scope is an additional qualification expected from contractors in green building projects' preconstruction services.

Although the life cycle cost analysis can be included in the schematic design stage, it would provide more detailed and precise calculation opportunities if this task is undertaken at the detailed design stage. Achieving high performance levels during the life cycle of a building may come with premium costs to the project. Owners may be concerned with premium costs and the only way to present whether the premium costs provide savings is to perform a life cycle cost analysis. The added premium to initial investment makes the life cycle cost analysis crucial during the preconstruction phase. Performing life cycle cost analysis would be appropriate in design development stage since the closely related value analysis is also initiated at this stage. The overall performance of the building can be directly measured and optimized by proper commissioning planning efforts. These efforts should initially take place in the schematic design stage and be further detailed in the design development and construction documentation stages.

The changing technology aspect of the green building projects is not limited to the innovative and new technologies. Sustainability also brings new concepts to building design such as prefabrication or deconstructability. For example, partial or complete prefabrication of building components may facilitate the higher rates of production efficiency while minimizing waste. There is a significant need to explore the potential of prefabrication options within the building industry in the United States. Although it is not a new concept, so far, it has not been a common practice. To give an example, precast concrete use in the building industry in the United States is only about 1.2% \(^\text{11}\). On the other hand, deconstruction is a relatively new concept which fosters the reuse of building elements and preservation of virgin materials \(^\text{12}\). Deconstruction is also having difficulties in becoming a mainstream practice because of low market demand and cost and time of material recovery among others. The preconstruction services presented in this paper...
does not include specific building certification procedures such as the LEED rating system which may require additional documentation and legal compliance issues as a part of the services.

**Summary and Conclusions**

The type of the project delivery method and timely involvement of the contractors in the decision making process have a significant impact on cost, quality, and sustainability goals of the construction projects. Design-Build and CM at Risk delivery methods provide an early opportunity for the contractors to participate in the process. Majority of the top green building contractors in the United States maintain significant experience and expertise in CM at Risk delivery method which places a large big emphasis on preconstruction services.

The preconstruction scope of green projects mainly differs in its intention to integrate the preconstruction analysis and planning with the performance of the building in post-construction and sustainable construction principles. The tasks focused on post-construction performance such as the utilization of renewable sources, sustainable and efficient energy technologies, and life cycle cost analysis are the examples of additional considerations brought into the preconstruction services of green building projects. The required collaboration between project stakeholders throughout the green building delivery process, certainly takes the issue of leadership and management into focus for contractors. The charette which is provided in the conceptual stage is a perfect opportunity for contractors to establish their leadership in the process.

There is an intense focus on the post-construction phase of green buildings during the preconstruction process, because eliminating the negative impacts of buildings to the environment is the primary focus of green building design and construction. Buildings are responsible for approximately 37% of all energy used in the United States which is composed of 68% of all electricity, 88% of potable water supplies, and 40% of raw materials. Buildings are also responsible for generating more than one third of municipal solid waste streams and 36% of total emissions of anthropogenic carbon dioxide emissions. However, to achieve high performance goals during the life cycle of a building, precise study is required during the preconstruction stage. Therefore, the green building project delivery should place more emphasis on the integration of stakeholders. Understanding the fundamentals of ecology is crucial in order to better perform especially in the preconstruction process of the project. Having the awareness and understanding of ecological concepts will help construction companies make sound decisions in selection of materials and energy systems technologies. The scope of constructability reviews and value analysis studies will be widened due to the ecological input to materials and energy systems' technologies.

To properly lead the green building projects, contractors are expected to possess the ability to analyze innovative technology scope, use building information modeling technology, perform energy modeling, possess a knowledge of ecology, and perform building life cycle cost analysis. Analyzing the new developments affecting construction management practices is important. They continuously need to be integrated to respective construction management courses’ contents. By bringing the latest developments into classroom, students will not only benefit from
... but also develop awareness about different qualities expected from construction professionals.

Bibliography


