Resilient Structures and Sustainable Construction
Edited by Pellicer, E., Adam, J. M., Yepes, V., Singh, A., and Yazdani, S.

ISBN: 978-0-9960437-4-8

OPTIMIZING GREEN-BUILDING PROJECT DELIVERY: COMPARATIVE ANALYSIS OF DESIGN-BID-BUILD AND DESIGN-BUILD DELIVERY METHODS USING CASE STUDIES

ALESSANDRO ORSI[1], EUGENIO PELLICER[2], and IGNACIO GUILLEN GUILLAMON[1]

[1]*School of Architecture, Universitat Politècnica de València, Valencia, Spain*
[2]*School of Civil Engineering, Universitat Politècnica de València, Valencia, Spain*

The development of a green-building project following a specific reference standard, such as LEED or BREEAM, brings new conditions and restrains for all subjects involved in the process. Within this scope, project management plays a key role for the optimization of the design-project development. This research develops a comparative analysis between the design processes of two case-study projects from the project management perspective, taking into consideration all the activities that negatively affected the project design development. The first project design was developed following the so-called "design-bid-build" process with the fragmentation of the process where each subject and technician involved worked independently from the others. The second project design was developed following a "turn-key" philosophy using a completely integrated process. A new methodology was created in order to analyze the project and evaluate the effects of detected project-management issues under three different points of view: costs, time and building sustainability. Such issues were identified by researchers on the basis of the Lean-definition of "waste". The results showed that process integration affects considerably the cost, schedule and sustainability level of the project design and vice versa, the accuracy of the project management tasks affect the sustainability features of the final building design.

Keywords: Project management, Lean, Sustainability, Project optimization.

1 INTRODUCTION

The differences among construction processes affects projects developed at international scale (Horman *et al.* 2006). The most-used green-building protocols implemented world-wide proceed from the Anglo-Saxon reality (Crea 2013) and were built on the basis on their specific construction process. On the other hand, Europe has an almost unique construction system (Guy and Moore 2005) that varies from country to country but it is consistently different from the Anglo-Saxon one (Quilty-Harper 2011). Literature review helped researchers establishing the following core-concepts for the development of the research:

- The implementation of specific protocols, such as, green-building protocols within a building design process brings additional restrictions to the process development (Riley *et al.* 2007).

- Such restrictions cause a constriction of the margin of maneuver of each subject involved in the process (Lenfle 2008).
- The whole process management and organization has to be refined in order to meet the new task restrictions.

This study aims to analyze the project management issues occurred during the design process of different green building projects. The "research rationale" makes full use of some lean-philosophy concepts in order to rationally sort out information throughout the whole process (Lapinski *et al.* 2006). The whole research is based on real case-study projects and has been carried out through four different stages:

- Data collection and process illustration.
- Process analysis and detection of project-management issues.
- Estimate of the impact of project-management issues on project costs, schedule and sustainability.
- Comparison between the case-study projects.

Researchers developed the present work with three main goals:

- The validation of a new methodology to analyze sustainability-related issues within the development of green-building design projects.
- The evaluation of the impact of the sustainability-related issues on the whole design development in terms of costs, time and sustainability facets.
- The evaluation of the impact of integrated process delivery methods for green-building design process.

2 RESEARCH METHOD

This research is carried out using a qualitative research approach, having the comparison of two case-study projects as the main research method. This exploratory approach is appropriate for investigating a phenomenon in its current scenario (Yin 2003). Researchers collected the data in three different ways: document analysis, participant observation, and personal interviews.

Project documentation was provided by the project owner and included all information related to each step, activity or event affecting the design phase from the early stage until the final stage. Researchers developed a bar chart listing all main activities of the design development process. Interviews to technicians and personnel involved in the project were personally made by researchers using a common procedure for all interviewees. Each subject recognized the problems they encountered during the design process and matched them with the list of project activities. The concept of "problem" was defined on the basis of the "waste" definition provided by the lean approach. Any type of activity performed during the process that in spite of consuming resources doesn't bring added value to the final product (Liker 2003). Out of the seven types of waste identified for an industrial LEAN process (Liker 2003) for the purpose of this research only five types of problems were considered: waiting, transportation, extra-processing, extra-costs, and product defects.

"Problems" as identified by all subjects were the consequence of the structural issues researchers were interested in. Therefore, problems initially identified by technicians were gathered together in five "categories of issues" which represent the real causes of the problems:

- Lack of integration between technicians.
- Misunderstanding of Commissioning Authority's tasks and process.
- Lack of appropriate clauses in bid documentation.
- Systematic cuts to budget due to change-orders and delays.
- Lack of knowledge about energy modelling role and process.

3 CASE STUDIES

The choice of these two case-study projects was made on the basis of the following statements:

- Direct access to project information: researchers could directly contact all the managers and technicians that worked on the project.
- Simultaneous research and design development: researchers could directly access project data and live-exchange information with the subjects involved.
- Green-building protocols: both case-study project consider sustainability in relationship with a world-class reference standard (LEED and BREEAM) as benchmark for evaluation.
- Project similarity: both projects analyzed are public projects and have similar features in terms of budget, footprint and time-frame for the design development.

3.1 Nursing Home Project

This case-study refers to a new nursing home complex located in Volano, Northern Italy. The project is currently being certified under the LEED for Healthcare 2009 protocol, has a total budget of approximately 11 Million Euros and a total gross footprint of 5,763 square meters. The project is owned by Opera Romani, a public entity which is controlled by another public agency, the local healthcare society. Project funds proceed from two main lines, both of them public. The project followed a typical DBB European process in which all design phases come before the general contractor and are performed by different subjects. Specifically in this case subject involved for the design development were:

- Architect: a small architectural studio located in Ravenna (central- Italy).
- Structural Engineers: a large company of engineering located in Venice (western Italy).
- Mechanical Engineers: a medium engineering firm located in Rome (central Italy).
- Assistant Project Manager: a single professional located in Rome (central Italy).
- LEED Accredited Professional: a single subject located in Trento (northern Italy).
- Energy modeler: a mechanical engineer subcontracted by mechanical engineers and located in Mississippi (USA).
- Commissioning Authority: a small engineering company in Brescia (northern Italy).
- Project owner: the public society cited above located in Trento (northern Italy).

The project design started on the 15th of April 2012 following the Italian DBB system which had two main phases called: "definitive" and "executive" design. Each phase had to be

developed by designers and then approved from both public entities controlling the project. This created a circular and reiterative information flow for authorization procedures, where owners and technicians had to decide and approve each other's work. The LEED protocol was taken as a reference since the beginning however, LEED-related professionals were hired only later during the design-development process. The design phase ended on the 14th of May 2014 leaving behind several sustainability-related issues. The total budget for the development of the design stage at the time of the contract sign was 520,000 Euros and the LEED points expected were 82.

3.2 Office Building

This case-study refers to a new office building located in the South of Spain, certified under the BREEAM Protocol with a total budget of approximately €14 Million and a gross square footprint of about 14,000 square meters. This public project was developed following the European Design-Build delivery method which reflects consistently the U.S. organization layout. Due to the confidentiality of project information, researchers cannot cite all information acquired. The whole process was set up with a single bid to the general contractor which had to develop the final design phase and the construction of the building. Subjects involved in this case were:

- Owner: represented by the public agency.
- General contractor: represented by a Spanish construction company which had an in-house technical office for the development of the building design and shop drawings.
- Project manager: represented by a private company contracted by the owner with the scope of overviewing the entire process and report eventual contract breaches.

The design was developed in two phases called "basic design" and "executive design", in a total period of four months. The original bid included design plus construction and, at the moment of the owner-GC contract sign, every project feature was sealed by contractual clauses. All specifics related to the design features, scheduling and BREEAM points were part of the contract. The general contractor developed both design phases as agreed upon the original contract in four months with an expected BREEAM score of 73.25%. The total budget for the development of the design stage at the moment of the contract sign was 515,000 Euros.

4 RESULTS

Information resulting from the present research were divided into three groups respectively related to three types of waste: delays in project completion, money spent over budget (direct and indirect costs) and loss of sustainability points. The term "direct costs" refers to all expenses, caused by the sustainability-related problems that the owner had to bear in addition to the original project budget in order to complete the design process. The term "indirect costs" refers to: all additional costs that technicians had to bear with no compensation to their fee. All additional costs which affected third parties and later project development phases are:

(i) Lack of integration between technicians:

(a) No general project manager was overviewing the whole process and this led to several issues. The choice of getting a commission to evaluate the green-building features of the design proposals instead of one single expert led to a delay of 2 months and an additional cost of 5,730 Euros. The lack of coordination with the homeland technical services led to the loss of 2 LEED points.

(b) No problems related to project manager role were detected for the development of the design process.

(ii) Misunderstanding of Commissioning Authority's (CxA) tasks and process:

(a) The CxA was contracted after the final approval of the project and had no time to summarily analyze the project spotting gaps in the project design and documentation. CxA-related documents such as OPR and BOD had to be re-defined and project gaps led to change orders during construction phase. Direct costs of this re-manufacturing activity were €8,000 plus €30,000 during the later construction phases. Indirect costs arose to €500 with a loss of 1 LEED point and 21 days of project delays.

(b) No extra cost was detected for CxA-related tasks on the other project in Spain.

(iii) No appropriate clauses in bid documentation:

(a) No specific clause was introduced in the bid for the development of the LEED documentation. This task was then overpriced by technicians for a direct extra cost of €30,000. Bid was also re-formulated due to legal inconsistencies for a total direct cost of €5,000, indirect cost of €1700 and 15 days delay.

(b) No project-management-related issues were registered for the scope of this work. A change order of the owner raised the BREEAM certification level from the bid-contracted 73.25% to 86% but was not considered by researchers.

(iv) Systematic cuts to budget due to change-orders and delays.

(a) The two-year duration of the design development brought to price increase and deficits in the project budget. The project had to be re-arranged also for the sustainability-related aspect. The total direct cost for the design change orders was €60,000 of which 5,000 were related to sustainability features, indirect costs accounted for €4,400; 4 LEED points were lost and 62 days were spent for project re-manufacturing.

(b) Project requirements and building features remained unchanged from the early start to the end of the design development.

(v) Lack of knowledge about energy modelling role and process.

(a) Energy modeling was included in the bid and designers tried to develop it but after several attempts they could not. An external energy modeler was then contracted after the final project approval. This led to an indirect extra cost of the energy modeler of €10,500; a loss of 7 LEED points under the credit EA 1 and 20 days of project delay.

(b) The energy modelling was carried out in-house by the design firm and this avoided any type of mistake or misinterpretation between technicians involved.

The implementation of the Design-Bid-Build delivery method demonstrated the following disadvantaged compared to the Design-Build for green-building design development:

- Reduction of process fragmentation in terms of number of subjects involved, geographical location and size of the companies engaged.
- Increment of design process schedule by 175 days for a design-delivery process of 2 years for the DBB project whether the DB project was designed in 4 months;

- Loss of 14 LEED points out of 82 which represent the loss of 17% of the sustainability project features;
- Total cost increase of €100,830 which represents an extra total cost of 19.6% with respect to the original budget for the design development.

5 CONCLUSIONS

With this work researchers developed a new methodology for the evaluation of green-building project delivery methods from a qualitative and quantitative perspective. The methodology allowed the identification of the project-management-related problems occurred during the project design development with the implementation of construction-management and Lean principles. The research showed the advantages of implementing a Design-Build versus a Design-Bid-Build delivery method for the development of green-building projects. The comparative approach followed by researchers allowed a quantitative evaluation of the potential margins for project optimization.

The magnitude of the project-management issues identified with the present research, which account roughly for the 20% of wasted resources in terms of time, costs and sustainability, highlights the mutual dependency between project management and green-building project features. Not only the introduction of green-building features affects the cost and scheduling of the design stage from the project management perspective but also the accuracy of the project management tasks affect the green-building features of the final building design. Therefore, researchers conclude that project management should be considered sustainability-enhancing.

References

Crea, J., *IFC and World Green Building Council Announce Global Partnership to Accelerate Green Building Growth*, USGBC Media, July 2013.

Guy, S., and Moore S. *Sustainable Architecture – Cultures and Natures in Europe and North America*, Spon Press, 2005.

Horman, M. J., Riley, D. R., Lapinski, A. R., Korkmaz, S., Pulaski, M. H., Magent, C. S., and Dahl, P. K., Delivering Green Buildings – Process Improvements for Sustainable Construction, *Journal of Green Building*, 1(1), 123-140, 2006.

Lapinski A., Horman M., and Riley D., Lean Processes for Sustainable Project Delivery, *Journal of Construction Engineering and Management*, 132(10), 1083-1091, 2006.

Lenfle, S., Exploration and Project Management, *International Journal of Project Management*, 26(5), 469-478, 2008.

Liker, J., *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer* (3rd Ed.), McGraw-Hill, 2003.

Quilty-Harper, C., *How bureaucracy is slowing Europe's recovery: Regulations and poor administration have held back Portugal, Ireland, Italy, Greece and Spain's economies*, The Telegraph, 21 Nov 2011.

Riley, D. R., Grommes, A. V., and Thatcher, C. E., Teaching sustainability in building design and engineering. *Journal of Green Building*, 2(1), 175-195, 2007.

Yin, R. K., *Case Study Research: Design and Methods* (3rd Edition), Sage Pub., 2003.