Abstract

Title: INTEGRATION OF DESIGN AND CONSTRUCTION THROUGH LOCATION-BASED PLANNING TOOLS IN OVERLAPPED PROJECTS

PhD Researcher: Clarissa Biotto – clarissa.biotto@hud.ac.uk – University of Huddersfield, UK.

Supervisors: Mike Kagioglou, Lauri Koskela and Patricia Tzortzopolous – University of Huddersfield, UK.

The overlap of design and construction stages is a current practice in the construction industry, in order to shorten the project lead time and cost. Apart from the construction industry fragmentation and its difficulties imposed to project management, this type of project faces some additional challenges, such as difficulties in optimising the design solution in a short period and in keeping the construction activities flowing smoothly. Furthermore, the advantages of this practice may be minimised if the time is poorly managed, resulting in over costs, time delays and an increase in uncertainty. Although these problems can be avoided using lean management practices, there is a lack of research on the application of lean and production management tools for designing, planning and controlling projects with overlap between design and construction stages. Moreover, the current literature in planning overlapped projects explores traditional methods of planning, such as CPM (Critical Path Method), which have limited capacity to deal with the construction complexity. Hence, research on the use of lean tools for planning, namely location-based tools, are needed and have a wide field of exploration to improve the performance of overlapped projects.

This research aims to develop a model for production design, plan and control for projects with overlap between design and construction activities using Location-Based Scheduling (LBS) and lean construction tools. As objectives, the researcher intends: (a) to explain how to devise an integrated planning and control system for design and construction considering their overlap; (b) how a construction package can pull supply and design processes; (c) how suppliers' and designers' work packages should be assembled in concordance with construction packages; (d) how should be the integration of design and construction systems operation regarding the activities control.

The knowledge basis to achieve these objectives come from an in-depth literature review on lean design, production and construction management to understand how lean manufacturing integrates overlapped systems using concurrent engineering and Just In Time (JIT) systems; understand how work packages are assembled in manufacturing and construction; what information should be integrated into design, supply chain and construction; what are the lean tools used to plan and control design and construction activities, and so on.

The research approach in this investigation was the Design Science Research (DSR). The DSR is a mode of producing scientific knowledge through the iterative process of developing, implementing and testing a solution (an artefact) for a problem that has relevance for practice and theory. In this research, the artefact is a model to design, plan and control lean production systems in projects with overlap between design and construction stages using LBS tools. It has been built along different types of studies: 1. retrospective practitioner studies; 2. case studies; and 3. action research study. In each study, the project management has been analysed regarding processes, tools and people.

The retrospective practitioners studies were carried out by the researcher during her professional experience as a lean consultant in Brazil between the years of 2012 and 2015. Three projects were retrospectively analysed: an aquarium project; a customisation of residential units

department; and all 23 departments of a construction company, with emphasis on the design and construction departments. In the first retrospective study, the relationship between designers, contractors and project managers was verified regarding the use of the Line of Balance (LOB) to plan and control the production of design and construction. In the second study, data was collected to investigate the integration promoted by the LOB regarding the customisation processes and the construction activities. In the third retrospective study, the alignment of departments' processes with the design development process was inspected. These three studies enabled the creation of the first version of the artefact of this research. Further, it was evaluated by five academics in the lean construction field, who provided feedback for the model refinement.

The first case study was carried out in August 2017 at the construction project of the Faculty of Fine Art, Music and Design (KMD) in Bergen, Norway. The project's participants interviewed in this study were the Head of the Project, who represented the owner; the Head of Architects; the Lead of Construction Engineering Design; the Design Manager; and the User's Consultant Manager. Both design and construction stages were planned and controlled by the takt-time planning, which is also a LBS tool. The case study led the refinement of the first version of the artefact into its second version, which was also evaluated by the case study's participants.

At the moment of the writing of this abstract, a second case study was planned to occur in December 2017 in the construction of 5-floor apartments building in Trondheim, Norway. The study aims to investigate the integration of design and construction through the use of collaborative planning by designers and builders. This study will contribute to the refinement of the second version of the model into its third version.

The last study, but not the least, was an action research study conducted between September and November 2017 in the construction of a maintenance area of highways in the north of England. It was part of a lean construction course led by the researcher at the University of Huddersfield. The course promoted the implementation of the LOB, Last Planner System, and pull design information to meet the construction requirements. However, the data created in this study still needs to be analysed to be embedded into the final version of the model.

Initial findings indicate the possibility of using LBS tools to design, plan and control the production of design, supply and construction. These tools improved the collaboration between designers, contractors and project managers because it enabled the visualisation of all processes the project's stakeholders needed to go through. After understanding the stakeholders' interdependencies, the teams made integrated decisions considering aspects of design and construction. Thus, the LBS tools can be considered a mediating artefact to manage projects with overlap between design and construction stages.

Moreover, the benefits of the tools extended beyond the collaboration and shared understanding. It tackles the technical aspects of the project, regarding the use of a common location broken down structure for designers, suppliers and builders work together. The use of location-based tools integrated between design, supply and construction can reduce the production batch size, the activities cycle time, the overproduction between stages, and increase the plan transparency.

The final model of this research can be used in the project management of construction projects with overlapping of design and construction phases, for example, fast-track construction, flash-track construction, and projects with concurrent development of design and construction

stages. These findings may improve the lean management theory and open a field for the further development of lean planning tools for integrating the production of design and construction.