AN EMPOWERED COLLABORATIVE PLANNING METHOD IN A SWEDISH CONSTRUCTION COMPANY - A CASE STUDY

Mikael Viklund Tallgren[1], Mattias Roupé and Mikael Johansson

Department of Civil and Environmental Engineering, Chalmers University of Technology, Göteborg, Sweden

The construction industry has seen several takes on planning methods, both in theory and in practice. One such initiative is the planning part of the Last Planner System (LPS) of production control, which has both been theorized and implemented at various degrees. However, with new developments in e.g., Building Information Modelling (BIM), it is relevant to study how an LPS implementation can be supported and improved with help of BIM. In particular it is interesting how BIM can be used to facilitate and enhance LPS in the phase planning. Furthermore, it is relevant to explore how BIM can enhance the understanding of the project at hand. For this a study was conducted on how a method inspired by LPS planning currently is applied in one of the larger construction companies in Sweden. The aim of the research is to describe the utilized planning method and explore possibilities to enhance the method. The research was conducted through observations of three full day workshops utilizing the method, complimented with a number of interviews. Strengths and weaknesses as well as its current use were identified and analysed. The observations, interviews and literature confirmed that the method is effective as well as presented indications that the current implementation of BIM in parallel with the method leaves room for improvement.

Keywords: BIM, construction planning, empowerment, information management.

INTRODUCTION

The construction industry is regarded as proficient in planning and scheduling (Zwikael 2009), but still has problems keeping budget and schedule (Christiansen 2012, Zwikael 2009). The literature shows that efforts focus mainly on refining current methods and improving the centralized specialist planner's role in early phases as well as production, meaning that current hierarchical structures are improved and reinforced (Christiansen 2012). Specialist planners base their production plans and schedules on plans formed during the tendering stage which means that assumptions made early in the process become the foundation for later decisions (Winch and Kelsey 2005). To balance this it is argued that the site-manager should take a more active role in planning. But as Winch and Kelsey highlight, there is a divide between interest and competency between the specialist planner and the site-manager. The specialist planner holds a more strategic view spanning several projects. However, the specialist planner lacks the knowledge of the practical work methods, an area in which the site-manager excels. In contrast, the site-manager lacks the time needed to actually perform the planning. The site-manager may also have a shorter perspective, focusing

[1] mikael.tallgren@chalmers.se

Viklund Tallgren, M, Roupé, M and Johansson, M (2015) An empowered collaborative planning method in a Swedish construction company - A case study *In:* Raidén, A B and Aboagye-Nimo, E (Eds) *Procs 31st Annual ARCOM Conference*, 7-9 September 2015, Lincoln, UK, Association of Researchers in Construction Management, 793-802.

foremost on the project at hand (Styhre and Josephson 2006, Winch and Kelsey 2005). Consequently the plans and schedules generated by the specialist planner are often seen as unachievable and used as mere guidelines at the construction site (Winch and Kelsey 2005). One way to gain a better acceptance of the plans is to use inspiration from lean manufacturing such as empowering the workers in the production (Liker 2005). Lean concepts have been adapted through lean construction and over the years, tools has been developed that address the weaknesses highlighted. One of these tools is last planner (Ballard and Howell 2003a). One of the key aspects in last planner is the fact that the detailed planning is postponed to the last possible moment. The planning is performed by the last possible person responsible for the work, hence the name last planner. This clearly exemplifies one kind of worker involvement and empowerment. But to fully gain the benefits of empowerment the reasons for being empowered needs to be understood and accepted by the workers (Dainty *et al.* 2002). When the actual stakeholders participate, the effect of their involvement gives higher quality input and better decisions in the planning processes. Especially since they bring tacit knowledge of the processes that seldom is transferred in any other way than by person to person, thus contributing with the right information at the right time (Büchmann-Slorup and Andersson 2010).

Apart from this, the literature also shows that there is a theoretical support for Building Information Models (BIM) enhancing lean concepts, and that BIM has the potential to support and enhance the implementation of Lean in construction (Sacks *et al.* 2010). One such enhancement in Sacks *et al.* (2010) is the visualization of BIM coupled with schedules, also known as 4D. In fact, Formoso *et al.* (2002) conclude that visual communication increases understanding of problems and participation of workers. However, the literature also shows that most implementations of 4D software today do not support work methods in their current form. Instead, there is a need to adjust work methods and processes to fit the tools, creating a technology push. This push hinders the use of the tools, since the time to learn new tools is not available in projects at the construction site. To address this, a tool should be adjusted or developed through current processes. By enhancing the processes the tool would create a demand, a technology pull, and thus a greater adoption (Hartmann *et al.* 2012).

This research focuses on the use of an empowered collaborative planning process at a Scandinavian contractor 'ConstructionCo'. The main aim of this research is to describe the usage of the method and study the interaction with BIM during the use of this planning method. The second aim is to explore possible areas of enhancements of the method. Thus the research questions are:

1. How does the used planning method relate to last planner?
2. How are the benefits of collaboration visible in the planning?
3. How is BIM used in the planning method?

LITERATURE REVIEW

The construction industry is generally viewed as a complex industry due to the great number of actors participating in a project. This can be traced to the high specialisation in separate trades resulting in complex work-site organisations. The complexity introduces uncertainty and to handle this uncertainty production control is introduced through planning (Dvir *et al.* 2003). Spending time on planning prior to the work on-site commences has been shown to be beneficial. The effects are shown as increased effectiveness in terms of better quality of the plans, as well as better-utilised

time and lower costs tied to planning (Faniran *et al.* 1994). It has also been argued that to increase planning effectiveness, goals as well as functional requirements of the project need to be clear as early as possible. This means that an early and continuous involvement of the end-user is critical throughout the whole construction process (Dvir *et al.* 2003). Research into the field has focused on effectiveness of the planning, but not as much into what the planners actually do (Winch and Kelsey 2005). Laufer and Tucker (1988) points out that planning is often done utilizing a specialist planner, with the rationale to reduce costs for planning (Faniran *et al.*1994). This is criticized by Winch and Kelsey (2005) due to the fact that specialist planners can only plan to a certain level of detail due to lack of practical knowledge. To increase precision in the planning, the planners research and gather information to form better decisions. This is a time intensive task for the planner (Winch and Kelsey 2005). As a counterpart to this, the literature argues that the use of decentralization reduces planning time and increases planning effectiveness. This implies that worker involvement is beneficial.

In fact by decentralizing the planning, the one actually performing the work can contribute directly to the planning, which reduces guesswork in the planning process originating from poor knowledge of the practice of certain work-methods (Dvir *et al.* 2003, Faniran *et al.* 1994, Laufer 1992). From a more general perspective of the construction industry, it is concluded that employee empowerment is largely overlooked or ignored. This could perhaps be due to the hierarchic structures that are prevalent in the construction industry. The fact that empowerment could help counter the negative effects of the fragmented structure of the construction industry has been shown through increases in productivity and job satisfaction (Dainty *et al.* 2002, Greasley *et al.* 2005). Empowerment and involvement is a vital part in lean manufacturing and especially in Toyota's Production System where people and teamwork are central for reducing waste and increasing quality (Liker 2005). The construction industry has approached lean through the adaptation of lean construction and this has resulted in tools such as the Last Planner System of Production Control (LPS) (Ballard and Howell 2003b, Fernandez-Solis *et al.* 2012, Hamzeh and Bergstrom 2010). In LPS, planning is broken down into different detail-levels of schedules, matching the available information in different steps (Hamzeh and Bergstrom 2010). Through the use of detail-levels the schedule gets gradually refined. The closer a task is being performed, the more detailed the schedule becomes. This ensures that the schedule is easy to maintain and update at each given moment, while at the same time keeping the schedule detailed enough. The main difference from the traditional process is that detailed planning is postponed to the last possible moment. At this moment the person responsible for conducting the work does the detailed planning (Ballard and Howell 1998).

In parallel with Lean construction the rise of BIM has been seen as an opportunity to achieve a more integrated design and construction process (Eastman *et al.* 2009). Furthermore, Sacks *et al.* (2010) describes a framework comparing the principles of lean construction with BIM functionalities, concluding that several BIM functionalities directly support lean construction concepts. As such BIM and lean construction probably could benefit by parallel implementation (Sacks *et al.* 2010). Apart from carrying the information needed in the planning process, the BIM also helps in communicating up and down the organizational levels. Thus ensuring that what is being planned actually is what is being built (Büchmann-Slorup and Andersson 2010). The inherent fact that BIM builds upon digital information leads to

the tools used to consume and display the models. The digital planning tools available today mostly focus on making a more effective planning process in the traditional form. Some research has looked into how the planning could be automated, either partially or fully. However, this has received criticism since it creates a sort of 'black box' planning, where the human planner loses some control over the decisions (Waly and Thabet 2003). Waly and Thabet (2003) conclude that automation of planning decisions is undesirable and that the virtual construction environment should support the human planner in the decision-making process rather than disconnect him/her. In other research the models and schedules are merged into simulation files, but they could hardly be called planning tools since they need the plans to be constructed (Waly and Thabet 2003). In general these planning systems often prescribe planning being done in one software program and then connected to the BIM elements in another software program (Eastman *et al.* 2009). Furthermore, the new possibilities with the advent BIM have resulted in the models being pushed to the work-site without the regard of how they should be used and implemented in current workflows. This combined with new tools that do not support current work processes has led to the fact that adoption rate of the technology on-site is poor. Both these directions demonstrate a technology-centred focus rather than support for current practices. This type of development could be interpreted as technology push (Hartmann *et al.* 2012).

Summarizing, planning is used to decrease uncertainties, but the use of specialist planners distances the planning from the workers. Research has focused on planning effectiveness rather than viewing planning as an action, thus increasing the distancing of planners from the actual workers. Studies show that BIM could help remedy this distance by acting as a communication and information carrier, but the tools that are currently available do not fully support this.

METHOD

The research was conducted as a single case study complimented by initial interviews and a literature review. The research was divided into four stages. First, the literature review followed by the interviews as the second stage. These two stages served to gain background knowledge of general theories in planning and scheduling as well as knowledge of how people participate in the planning approach. The third stage included observations of the case study workshops in practice. This then led to the fourth stage, the analysis and comparison of the observations with the literature. The reason for the initial interviews were to identify how each of the sub-contractors in general approached planning of their activities, both in terms of information gathering and information processing during their planning process. The interviews were conducted as semi-structured interviews, allowing for some elaboration of details while still receiving a baseline of information among the sub-contractors. Since the project that was to be studied had not started, the interviews were held with personnel not connected to the actual case study, but involved in a similar project. The interviews were conducted with seven interviewees during one-hour interviews, which were recorded and later transcribed in verbatim. The interviews were held on-site with one worker from the prefabrication sub-contractor, two workers from the ventilation sub-contractor, one from the plumbing sub-contractor, two from the sprinkler sub-contractor, one from the electricity/safety sub-contractor and lastly one from the site supervision. An additional interview with the specialist planner behind the workshops, called Location-based Production Planning (LPP), was conducted off-site in order to understand the background of the planning method. The main stage of the research was the observations of the LPP-method, conducted in two out of three possible

workshops. The workshops were conducted as business-as-usual; the corresponding author had the possibility to participate in the daily businesses. The main objective was to observe and record the LPP-method in action. The participation enabled a deeper insight in how the method and workshop interacted. The corresponding author had a role as the model-navigator, because the intended model-navigators of the case ConstructionCo could not participate. The corresponding author introduced himself as a researcher with knowledge in the field of BIM-models and visualisation and was accepted without further questions. The workshops were documented through field-notes after each workshop. These notes together with the interviews were then coded through open coding, gathering significant keywords that pointed at key categories forming themes of interest (Flick 2009). The categories of themes found were; participation, information gathering, navigation, communication and technology. These were used to connect results to the literature.

Research case study

ConstructionCo is one of the leading construction companies in Sweden and Scandinavia, working with everything from infrastructure to housing and commercial properties. In a few projects a new collaborative planning method has been introduced and used during the last couple of years. This system for phase planning in the pre-construction stage has been successfully used in a series of similar projects conducted throughout Scandinavia. The system was put into place by one of the specialist planners at ConstructionCo, in an effort to counter the mistrust in the schedule, as it exists in projects today. The method strives to involve all actors with interest in the process in the planning and scheduling of the construction. The planning method differs from the traditional process in such a way that each sub-contractor has a representative, usually the supervisor or senior fitter, attending. In general the method could be illustrated as consisting of at least two workshops, one for the assembly of the construction schedule, and one for the adjustment of the schedule, with the digitalization of the schedule in between these workshops. Two main points are important in these workshops, the creation of activities by the participant and the collaborative sequencing of these activities. Each participant is responsible to plan and schedule quantity take-offs (QTO), resources and durations for every activity they are responsible for. These activities are then sequenced in a collaborative way where all participants partake.

Currently, five projects have been conducted with this LPP-method. All of the projects have been shopping centres throughout Scandinavia. The project studied in this study was situated in southern Norway, with ConstructionCo as the main contractor. The project was fully modelled in BIM software, but each discipline used different software programs, ranging from AutoCAD, MagiCAD and Revit to Tekla Stuctures. Thus the models where exchanged and coordinated in Solibri Model Checker (SMC) through the neutral file format IFC. Few of the participants where familiar with SMC, thus there were a need for a model- pilot when BIM was to be used. The workshops in this project were actual working workshops, conducted as usual in a conference room at ConstructionCo, with current architectural drawings, specifications and other documentation relevant for the project fastened on boards hanging on the walls of the room. As a compliment, two boards with the building subdivided into sub-zones and levels where present along with a coordination BIM-model projected on one of the walls in the model review-software Solibri Model Checker. All in all, the workshops had on average 16 participants, in which the client was represented as well as at least

one person from each sub-contractor along with ConstructionCo own site-supervisor and the specialist planner.

RESULTS

ConstructionCo has implemented a new way of conducting planning in a more collaborative way called LPP. The specialist planner behind the idea describes that the traditional planning process consists of the site-manager planning a schedule and then tries to sell this plan to the subcontractors and other consultants. The *"buy-in"* of the subcontractors and consultants is hard to get, and often the schedules are used only as loose guides at best. The LPP-method was introduced to mitigate this and to have all actors involved in the planning process. The fact that all actors are involved in the development of the schedule implies that there is no need for promoting and selling the schedule. The participants agree to the schedule at the workshop. This results in a transparent and open planning process where each of the consultants and subcontractors has their say in the timing and planning of their work. The specialist planner mentioned that experience from earlier projects that have applied this method is that there is less re-scheduling due to a greater *"buy-in"* and understanding of each contractor's role in the production. The specialist planner said:

"…Even though all actors in the production are gathered one or two times for the full day workshops, less time is spent on planning. It is also done with greater accuracy due to the practice knowledge put in by the participants…"

The specialist planner further identified two main areas of improvement (1) the BIM model was not used successfully; (2) the lead-time from the planning to the digitized schedule is too long. In total, the specialist planner has seen that his time spent on each project decreases as the reworking of the schedule is reduced.

The results of the interviews showed that the sub-contractors and the site manager in general receive their information and QTO from the descriptions and drawings they are supplied with. Furthermore, the interviews showed that different information was needed, depending on where in the building process the sub-contractors were active. The prefabrication sub-contractor needed little information from other actors. The information that they would like to have, but seldom received, was to which degree their building parts where to be visible. As they reasoned the precision of the fitting of their parts could be lowered if the parts were not supposed to be exposed and visible. Another notable insight was from the ventilation, plumbing and sprinkler sub-contractors, they used both their own documents as well as coordination drawings to gain the position of the other disciplines building parts. They noted that they seldom received the section drawings they wanted, with the argument that it was too expensive to produce them. Finally, the electrician concluded that since his discipline often was the last one in the process, he needed few of the others drawings, this was due to the fact that he had to adjust his parts to what was already built anyway. In general, the sub-contractors had heard of BIM but did not use it. Some of the sub-contractor saw benefits with BIM, such as that they with some help could have views and 3D-pictures of areas they were missing adequate section drawings for. This was especially true for the sub-contractors that had a high degree of coordination between disciplines.

The workshops

The main reasons for the workshops were to collaboratively accomplish a rough plan, corresponding to a more detailed phase schedule with locations. The general layout of

the workshops was a short presentation of each participant and their role in the project, after this a short walkthrough of the project was conducted, explaining the division in zones on each floor. The specialist planner had identified that the time for the first workshop was going to be scarce, so the zones of the building were prioritized according to the importance of completion. After the walkthrough, the workshop was divided into individual work were each actor listed his/hers activities in each zone and each of the activities were specified on sticky notes. Most of this work was done individually, but as questions of certain aspects of work relating to other sub-contractors work rose, the possibility to gain instant feedback and clarification led to a high degree of interaction between the participants. When all activities were specified, the collaborative planning commenced. The zones were planned in order from the most to the least critical. This meant going through each participant and sequencing their work at each given location, thus manually assembling the project through the sequencing. The sticky notes with the activities where arranged with dependencies on large pieces of paper sheets. After the sequencing a second walkthrough followed, this time going through the activities in the order planned. The manually assembled schedule was then digitized by the specialist planner in a planning software program and sent for review to the participants of the workshop. The second workshop was initialized because not all sub-contractors could participate in the first workshop, thus the full plan could not be assembled. This made room for some reviewing of the schedule from the first workshop. The first part of the second workshop was spent going through each of the zones such as they were planned at the last workshop, both as a recap and as an orientation for the contractor that did not attend the first workshop. After each zone had been reviewed, the contactor that missed the first workshop was allowed to plan his activities, while the rest of the actors added missing activities and adjusted already specified activities. The second workshop ended with a walkthrough similar to the one in the first workshop. The third workshop was centred on the agreement of the schedule; once again the model was walked through, but this time with the schedule as the focus.

Some general observations from the workshops were that most contractors were familiar with the way the workshops where conducted, since they had worked together on similar projects that also applied the LPP-method. The ones not familiar with the method were instructed and understood the method and its meaning fairly quickly. Another observation was that due to the fact that the zones were planned in order of complexity, it was hard to identify where each zone was situated in the model, as there was some crisscrossing during the walkthrough through the model. This even led to some activities being missed altogether, as mentioned above. The orientation problem became especially apparent when the actors tried to follow along on their plotted drawings in parallel with the BIM on the big screen. An overview of the different zones was plotted, but as it hung on a wall besides the big screen, some of the participants had a hard time to see and read it. At the second workshop it was concluded that it would probably have been easier to go through each zone in sequence of their respective location, thus virtually walking through the model, since some connections had been missed in the first workshop. The specialist planner stated that the crisscrossing in the model probably resulted in these missing connections. Even though the problem with following the BIM model, the use of the model contributed to a better understanding of the building. This was exemplified by the comments and questions around certain solutions that could be clarified during the workshop. It was also observed that the collaborative planning and the workshops helped bring the team together. This was especially true for those that had performed a

couple of projects together. This showed that the planning method helped the team bond as well as produce a mutually agreed-upon-plan. The collaborative planning technique and the use of the BIM helped to further the collective understanding. A final reflection from the workshops was also that the participants mentioned that the likelihood that they would pick up their phone and call one of the other participants if questions rose increased since they all had met a couple of times, thus lowering the barriers of communication.

DISCUSSION

The aim of the paper was to describe the use of a collaborative planning method as well as to study the interaction of BIM with this planning method and if BIM could enhance the understanding of the planning being conducted. The major findings are presented below.

LPP - A truly empowered collaborative planning process.

This research primarily contributes with a description of an implementation of an empowered collaborative planning method. The observations of the LPP-method workshops showed that interaction between participants was high and that questions were clarified almost instantly. The method of manually assembling the building activity-by-activity as well as location-by-location ensured that all sub-contractors were on the same page, this supports the fact that communication is enhanced (Büchmann-Slorup and Andersson 2010). From the interviews it was found that involvement reduces the time spent on re-planning supports the claim that involvement is critical (Dvir *et al.* 2003). The involvement also enables the participants to adjust and contribute to the schedule before they accept it.

As stated during the interviews, the workshops saved overall time spent on planning. The gathering of sub-contractors for a couple of full days may initially appear time consuming but the results show that it is well invested time for both the sub-contractors as well as the planner. This further supports that engaging the right persons at the right time reduces the need for guesswork in areas where the specialist planner may lack knowledge (Dvir *et al.* 2003). It also saves time spent on gathering information trying to remedy the lack of practical knowledge. The combined use of a big screen and physical drawings resulted in apparent confusion of which zone were being planned at the moment. Finally, the workshops showed that the gathering of all sub-contractors and other stakeholders in the production meant that the workshops functioned as a team building activity. The gathering of all key participants contributes to forming team relations early in the project, thus lowering the barriers for communication. The LPP-method has similarities with LPS-method, in that the persons closest to the actual execution of the activity are the ones responsible for the planning (Ballard and Howell 2003b). Thus the method could be seen as implementing a sub-set of LPS since it mainly focuses on the phase planning. The utilisation of the foremen and leading fitters of the sub-contractors can be argued as a way to empower the workers and gain a general agreement of the plan and schedule. Thus the kind of empowerment observed in the LPP-method is supported by literature (Dvir *et al.*2003, Faniran *et al.* 1994, Laufer 1992). The observed empowerment also shows that the benefits stated by Dainty *et al.* (2002) can be realised.

BIM – Still has weaknesses in implementation.

The second contribution of this research is the observations of how BIM is implemented in production planning. The interviews showed that the general BIM

knowledge with the workers in production is low, they had heard of it, but lacked practical knowledge in the tools. However, as stated in the interviews, even though the BIM model helped the workers to understand the work they were about to perform and plan it was not used to its full potential. The problem in the workshops was the barrier formed by not being able to fully navigate in the model. This could be related to the order of which the zones were planned, but also to the fact that the zone division was not clear for the participants since it was not visible in their plotted drawings. The mixed use of plotted drawings and the 3D model could also have contributed to the difficulty of following along. This obviously hampered the BIM's ability to enhance the understanding of what was being planned, but it is not comparable to the use of no BIM at all. The observations still support Büchmann-Slorup and Andersson (2010) in that BIM enhances communication throughout the organization, at least with regards to the on-site organisation. The use of the sticky notes on paper sheets are an effective low-tech approach to have the parties involved in the planning, but it still leaves room for improvement. Few tools for collaborative co-location planning exist and as stated earlier these are more geared towards traditional methods. The LPP-method as described in this research shows that its needs differ from the way traditional tools have been implemented, where they pair the BIM and the schedule after the plan has been established (Eastman *et al.* 2009). The observations in both the workshops and the interviews lead to the conclusion that the BIM should be able to be at the centre of the planning process. This warrants further investigation of how the planning with the help of BIM could be implemented and is supported by the statement by Hartmann *et al.* (2012) that existing processes should be aided rather than replaced.

CONCLUSIONS

This research shows that the method introduced by ConstructionCo is theoretically supported both in the general planning method as well as in the philosophy of empowerment and involvement. The method is described and documented in this research and through this the benefits of collaboration and involvement are visible. The similarities with LPS suggest that the benefits gained in LPS also are transferrable to LPP. Furthermore, strengthen the observations of LPP the contribution of LPS to the field of planning research as it shows a successful use of an LPS inspired planning method in practice. The use of BIM in the method in the observations were disappointing, the model tried to act as central medium, but the sub-contractors reliance on their plotted drawings hindered an effective use of the model. The greatest obstacle was the lack of orientation, stemming from the fact that they tried to map the location of the BIM on the big screen to where they were in the plotted drawings in front of them. Topics to explore in the future may be the interaction of BIM on big-screen with multiple users in planning and scheduling environments, possible enhancements of the activity of sequencing activities, as well as further observations of the VPP-method in different settings, especially in other types of projects.

REFERENCES

Ballard, G and Howell, G (1998) Shielding production: Essential step in production control. *Journal of Construction Engineering and Management*, **124**(1), 11-7.

Ballard, G and Howell, G (2003a) Lean project management. *Building Research and Information*, **31**(2), 119-33.

Ballard, G and Howell, G A (2003b) An update on last planner. *In, Proc., 11th Annual Conf., International Group for Lean Construction, Blacksburg, VA*.

Büchmann-Slorup, R and Andersson, N (2010) Bim-based scheduling of construction–a comparative analysis of prevailing and bim-based scheduling processes. *In*, *Proc., 27 th Int. Conf. of the CIB W78*, 113-23.

Christiansen, F (2012) *The planning process at a construction site*, Chalmers University of Technology.

da CL Alves, T, Milberg, C and Walsh, K D (2012) Exploring lean construction practice, research, and education. *Engineering, Construction and Architectural Management*, **19**(5), 512-25.

Dainty, A R, Bryman, A and Price, A D (2002) Empowerment within the uk construction sector. *Leadership and Organization Development Journal*, **23**(6), 333-42.

Dvir, D, Raz, T and Shenhar, A J (2003) An empirical analysis of the relationship between project planning and project success. *International Journal of Project Management*, **21**(2), 89-95.

Eastman, C, Teicholz, P, Sacks, R and Liston, K (2009) *Bim handbook*. John Wiley and Sons.

Faniran, O O, Oluwoye, J O and Lenard, D (1994) Effective construction planning. *Construction Management and Economics*, **12**(6), 485-99.

Fernandez-Solis, J L, Porwal, V, Lavy, S, Shafaat, A, Rybkowski, Z K, Son, K and Lagoo, N (2012) Survey of motivations, benefits, and implementation challenges of last planner system users. *Journal of Construction Engineering and Management*, **139**(4), 354-60.

Flick, U (2009) An introduction to qualitative research. Sage.

Formoso, C, Santos, A and Powell, J (2002) An exploratory study on the applicability of process transparency in construction sites. Journal of Construction Research, 3(01), 35-54.

Greasley, K, Bryman, A, Dainty, A, Price, A, Soetanto, R and King, N (2005) Employee perceptions of empowerment. *Employee relations*, **27**(4), 354-68.

Hamzeh, F and Bergstrom, E (2010) The lean transformation: A framework for successful implementation of the last planner tm system in construction. *In*, *International Proceedings of the 46th Annual Conference. Associated Schools of Construction*.

Hartmann, T, Van Meerveld, H, Vossebeld, N and Adriaanse, A (2012) Aligning building information model tools and construction management methods. *Automation in Construction*, **22**, 605-13.

Laufer, A (1992) A micro view of the project planning process. *Construction Management and Economics*, **10**(1), 31-43.

Liker, J K (2005) *The toyota way*. Esensi.

Sacks, R, Koskela, L, Dave, B A and Owen, R (2010) Interaction of lean and building information modeling in construction. *Journal of Construction Engineering and Management*, **136**(9), 968-80.

Styhre, A and Josephson, P E (2006) Revisiting site manager work: Stuck in the middle? *Construction Management and Economics*, **24**(5), 521-8.

Waly, A F and Thabet, W Y (2003) A virtual construction environment for preconstruction planning. *Automation in Construction*, **12**(2), 139-54.

Winch, G M and Kelsey, J (2005) What do construction project planners do? *International Journal of Project Management*, **23**(2), 141-9.

Zwikael, O (2009) Critical planning processes in construction projects. *Construction Innovation*, **9**(4), 372-87.