THE ROBUST SCHEDULE – A LINK TO IMPROVED WORKFLOW

Søren Lindhard[1] and Søren Wandahl[2]

ABSTRACT

In today's construction, there is a paramount focus on time, and on the scheduling and control of time. Everything is organized with respect to time. The construction project has to be completed within a fixed and often tight deadline. Otherwise a daily penalty often has to be paid. This pins down the contractors, and forces them to rigorously adhere to the initial schedule. If delayed the work-pace or manpower has to be increased to observe the schedule. In an attempt to improve productivity, three independent site-mangers have been interviewed about time-scheduling. Their experiences and opinions have been analyzed and weaknesses in existing time scheduling have been found. The findings showed a negative side effect of keeping the schedule too tight as it becomes inflexible and cannot absorb variability in production. Flexibility is necessary because of the contractors' interacting and dependent activities. Variability delays the process and results in conflicts between the trades. Moreover, a tight schedule does to a greater degree allow conflicts to be transmitted from one contractor to another. This increases the number of hot spots between contractors and produces more conflicts. The result is a chaotic, complex and uncontrolled construction site. Furthermore, strict time limits entail the workflow to be optimized under sub-optimal conditions. Even though productivity overall seems to be increasing, productivity per man-hour is decreasing resulting in increased cost. To increase productivity and decrease cost a more robust schedule is needed. The solution seems obvious, more time has to be released and more robustness has to be put into the schedule. The downside is that a postponed completion data often results in other costs for the client. Therefore, the deadline set has to be realistic. By introducing flexibility into the deadline negotiations can help achieve win/win situations bringing productivity and value creation up.

KEYWORDS

Lean Construction, Robustness, Work flow, Interview

INTRODUCTION

In construction as well as everywhere else *"time is money"*. Therefore, time is a competitive parameter and often the most important one. Everything is planned with concern to time. The contractor is in his contract forced to finish the project to a fixed

[1] PhD student, Department of Mechanical and Manufacturing Engineering, Aalborg University, Fibigerstræde 16, 9220 Aalborg Ø, Denmark, Phone +45 21848004, lindhard@m-tech.aau.dk

[2] Professor, School of Engineering, Aarhus University, Dalgas Avenue 2, 8000 Aarhus, Denmark, Phone +45 41893216, swa@iha.dk

completions date. If not daily penalties have to be paid, and the contractor is in risk for not allocating resources to other future assignments.

Time also serves as a central part in Lean Construction where any unnecessary time consumption is regarded as waste, c.f. the seven types of waste (Ohno 1988; Suzaki 1987). The Lean approach is through transformations focusing on adding costumer value to the end product. Meanwhile non value adding activities such as moving, waiting, and inspection are sought eliminated (Koskela 2000).

The scheduling tool Last Planner System (LPS) has been implemented at construction sites in the attempt to remove waste to make the production Lean (Ballard 2000a). A part of LPS is the Phase Scheduling process. Here the individual contractors collaboratively determine the sequence, bearing interactions and dependencies in mind (Ballard and Howell 2003; Ballard 2000b). The purpose of the sequencing process is to streamline the production and thereby remove waste. Through the making ready process, activities are made ready for completion (Jang and Kim 2008). This is done to decrease variability and thereby achieve robustness in the schedule. But still with respect to the fixed completion date.

Transition from traditional time scheduling to LPS, has increased the number of planned activities completed (PPC). Before LPS was introduced, the PPC level was approximately 50 %, after implementation the PPC raised to around 70 %. Furthermore, a decrease in non-productive time from 50 % to 35 % was recorded (Ballard 1999). Non-productive time only includes the loss of productivity which can be assigned to delays and rework. Indeed there is still, both reliability in planning and more essential productivity to be achieved (Lindhard and Wandahl 2012). Still 30 % of all planed activities do not finish as planned and still only 65% of all time is productive.

One way to increase the robustness of the schedule and thereby the PPC measurement could be by improving workflows. Even though LPS tries to manage and improve the workflows a change in the completion date is not considered. An extended deadline would decrease dependencies between contractors leading to a less complex construction project. The complexity is caused by highly interdependent activities, a lack of standardization, multiple components, limited space, and many trades and subcontractors represented on site (Ahmad and An 2008; Bertelsen and Koskela 2004; Bertelsen 2003; Ballard and Howell 1995). Thus leading to a production where different contractors perform overlapping and interacting activities. The result is increased uncertainty which make the construction process very difficult to schedule (Salem *et al.* 2006; Bertelsen 2003; Lindhard and Wandahl 2011).

This reseach looks into what happens if the preasure of time is relieved. The interdependenceis will still exist but the number of joints would be reduced. This reduces the number of conflicts. By extending the deadline a gab between interdependencies would make it more easy for the contractor to finsh on time. Moreover if enough time is releaviled the gabs will increase which make it possible to optimize the work of the contractors more individually. This creates a situation

where suboptimazion is acceptable as loong as the total process still is keept in mind. Finnaly, extra time would allow contractios to select cheeper production processes.

It is important to stress that an extension of the construction period also would cause negative effects. Firstly, there could be costs related to an extended deadline, for instance rental of other constructional facilities or loss of income. Secondly, the construction process might be more expensive since the rental period of heavy equipment might be prolonged. Therefore, the client has the final call when determining the completion date.

In an attempt to develop new approaches to suplement the existing scheduling tools the following reseach quesiton is raised.

"What happens to a construction project if more time is released? And could "win/win" situation be gained if more focus, with time consumption in mind, is on securing a more optimal process?"

The answer to this question is found by interviewing experienced site managers and by looking into the theories of Lean Construction.

RESEACH METHODOLOGY AND METHODS

Different research approaches capture different aspects from the world of construction sites. One approach is to capture knowledge by interviews or conversations. According to Burgess (1982) conversations are a crucial element in a field research. It is important to notice that interviews are more than a conversation it is a conversation with a purpose (Ritchie *et al.* 2005; Dexter 1970). Interviews can be *"used to make sense of and understand, on a daily basis, the world in which we live"* (Ritchie *et al.* 2005, p.100). They can be used to capture experiences from people and understand what meaning they make out of their experiences.

Interviewing is an approach to learning (Rubin and Rubin 1995). Kvale (1996, p.14) state it like this: *"the qualitative research interview is a construction site for knowledge"*. During the face to face interchange the interviewer is trying to elicit the needed information (Maccoby and Maccoby 1954).

Three site managers were interviewed in an attempt to capture their experiences with LPS to learn from practitioners (Seidman 1998). Therefore, when selecting interviewees it was a basic requirement that LPS was applied in a daily basis at current construction site. The interview was conducted as semi-structured following the interviewing guidelines presented in (Ritchie *et al.* 2005, p.106). The interviews were conducted individually for every site manager as a face to face interview. Before the interviews were conducted the site mangers and the interviewer meet in several occasions to gain mutual trust which according to Oakley (1981) is essential. Only the oral communication was of interest. This means that no interest was put into capturing kinesic, paralinguistic, or chronemic data.

Before the interview a number of open questions were prepared to help structuring the interview and making sure all important topics were covered. Wengraf (2004) suggest that open questions are prepared having in mind that questions cannot

be planned in detail, since the informants response cannot be predicted in advance. Therefore, questions must be improvised in a theorized and deliberated way (Wengraf 2004). The interviews were recorded in Danish and supported by additional field notes. Afterwards the data from the interviews were transcribed, analyzed, and translated into English.

RESULTS

In the following section the results of the interviews are presented. The site managers are made anonymous. Instead (B1), (B2) and (B3) respectively represent the three site managers.

LPS is implemented in the seeking of an increased robustness in the scheduling processes. When scheduling, the PPC calculation determines the quality or the robustness of the schedule. Therefore, the site managers (B2) *"seek for a PPC between 70 and 90%"*. This opens up rooms for non-completions which are important. (B2)*"If we do not take risks we get nowhere"*. Collaboration is important and we seek to involve the contractors in the scheduling process. (B2) *"Sometimes the schedule is kept sometimes not, but at least we are trying to schedule."*

The Phase schedule is very important. (B3) *"By determining the right sequence you speed up production and moreover often increase quality."* The sequence is tied to the fixed timeframe. *(B3) "It is within that frame the optimal sequence has to be found. (B3)"If no time limits were attached the cheapest solution would probably be that one man had to do all the work."* Therefore, time needs to be taking into consideration.

Even so the schedule is often too tight. (B3) *"Therefore, things have to be hurried and the result is increased expenses. This is wasted money."* (B1) *"The more activities you can complete on schedule the better workflow you will get because acceleration of work is cost full."* If more time were added to the construction process the workflow could be optimized. Maybe the number of trades could be reduced to make the scheduled tasks more foreseeable. With more time (B2) *"We could cut expenses by optimizing the sequence."*

In construction it is a tendency that (B3) *"contractors work best under pressure. Everything has to be complete in the last possible minute"*. It is a risk that the extra time I wasted. Therefore, one should only carefully extend the timeframe.

Still the timeframe has to fit the project. (B1) *"It is important to be able to keep a robust time schedule without accelerating the work.* The result of a too tight schedule is increased costs. (B3) *"Sometimes work accelerations forces the selection of foolish solutions where cost is neglected."* Therefore, a realistic deadline is important when talking total costs of construction. We build what the owner wants. (B3) *"To us work acceleration is waste but it is the owners call to set the deadline."* But of cause (s)he has other considerations (B3) *"maybe loss in turnover."*

One thing is cost of accelerated works. Saving could have been gained by selection cheaper production processes. At least the owner should be willing to negotiate to create a win/win situation. Thereby, savings would probably be gained. The final solution is not so important to us (B2) *"in the end the owner has to pay for what he gets."* With regards to quality, accelerated work should not have an effect a noticeable effect. (B3) *"We still have to deliver the agreed quality. Therefore, we cannot make compromises which affect the end product."* But still (B1) *"with more time we could deliver better quality."*

As a site manager working under pressure, sometimes you make poor decisions. To decrease the number of bad decisions (B3) *"we try to involve the people who are affected by the decision and together find the best solution."* This has proven very successful.

The low flexibility in project duration is often caused by a very traditional way of thinking and caused by contract bonds. Here, delay is resulting in daily penalties. This daily penalty is often very large forcing the contractor to finish on time. (B3) *"It sometimes even seems like the owner even speculates in daily penalties."* Therefore, (s)he is of cause not willing to give extra time for construction.

THE LEAN CONSTRUCTION THEORY

To show that extend time, even though it is regarded waste, can have a positive effect on the overall productivity the Transformation-Flow-Value (T-F-V) theory is shortly presented. In the T-F-V theory production is viewed as a flow of materials starting from raw materials and ending as the final product. The material flow is undergoing, moving, waiting, inspection, and transformation before the final construction is finished (Koskela 2000; Koskela 1992).

Every activity consists of a cost and time consumption. Only transformations are adding value to the product, the other activities are only expenditures in cost and time and can be regarded as waste. The concept is then to eliminate or minimize waste or non-value-adding activities and to streamline the value-adding activities to make them as efficient and as value adding as possible. (Koskela 1996; Koskela 1992)

Value is a fulfillment of the customer demand and requirements. Johnson & Kaplan (1987) defined value this way: *"value of any commodity, service, or condition, utilized in production, passes over into the object or product for which the original item was expended and attaches to the result, giving it its value."* To increase value generation costumer requirements needs to be defined. Every activity has in general two costumers, the following activity and the end costumer. To maximize value the needs for both costumers have to be determined and during transformations fulfilled (Koskela 1992).

A method to reduce waste is to simplify the process. This includes reducing the linkages and the number of steps in the informational or material flow and reducing the number of parts and components through production. According to Koskela (1992) *"the very complexity of a product or process increases the costs beyond the sum of*

the costs of individual parts or steps." Simplification can be achieved by a reconfiguration of the value-adding activities and by eliminating the waste activities. Other approaches could be prefabrication, modularization, or standardization of parts and materials etc. Moreover could it be achieved by decoupling linkages, and minimizing the needed information (Koskela 2000; Koskela 1992).

By simplifying the production process variability is decreased. A decrease in variability induces a decrease in the non value-adding activities and improves cycle and lead time (Hopp *et al.* 1990). Schonberger (1986) further stated that: *"Variability is the universal enemy"*. Approaches to reduce variability could be by eliminating the root causes, or by, as mentioned, simplification and standardization (Koskela 2000; Koskela 1992).

Lead time is defined as the sum of time applied to processing, inspection, waiting, and moving. Besides of a reduction of waste, a reduced lead time results in a faster product delivery to the customer and simplifies management. It increases robustness of the system because the recovery from upsets is more rapidly and less wasteful (Ballard *et al.* 2003). A more rapid response to upsets is increasing learning and project control. Thereby the need of buffers shrink, which reduces cost (Ballard et al. 2003). Approaches to reduce lead time could be reducing batch sizes, reduce waiting time, minimizing moving distances, smoothing and synchronizing flows, reducing variability, conduct activities in parallel order, or isolate the key value-adding sequence from support sequences (Koskela 2000; Koskela 1992).

An increased flexibility, gives an increased productivity and reliability. It improves the ability to respond on unforeseen events (Ballard and Howell 1995; Koskela 1992). Approaches to increase flexibility could be buffering, customizing as late in the process as possible, reducing difficulties of setups, a multi-skilled workforce, or finely by minimizing lot sizes to closely match demands (Koskela 2000; Koskela 1992). This leads to process transparence, which increases the visibility of errors and the motivation for improvement. Motivation can also be achieve or stimulated by benchmarking. Initiatives to gain transparence could be reducing interdependence between production units, create order, implement visual controls, measurements of the performance, and by making both the process and the instructions directly observable (Koskela 2000; Koskela 1992).

To hinder sub-optimization there need to be a focus on both the entire process and on each subprocess. One way to hinder sub-optimization is to establish an overview of the complete process and having the complete process process in mind when optimizing the subprocesses. To do this we should according to Koskela (1992) first measure the total process, and secondly implement an authority to control the entire process.

And finally the improvement in every aspect has to be continuous, and has to involve every employee. A tangible improvement can then be gained in small but steady steps (Koskela 1992).

DISCUSSION

In relation to Lean Construction and the T-F-V theory an expanded time frame is positive. Though still one should remember that time is considered as a source to waste. But could time be necessary waste to achieve improved production? A Removal of the fixed deadline will remove complexity this means less trades on site and more gabs between the interacting activities. Moreover, it will help simplifying the construction process and minimizing variability. This results in a more smooth construction process. Because of simplification waste is easier spotted and removed. By optimizing the work of the individual contractor lead time could be reduced. Finally, more robustness will be put into the schedule, which lowers the needs of buffers.

Even though more time will give a positive effect on production there is still two things which need to be considered. First of all cost has to be considered. An unrealistic tight timeframe will be inflexible. Because of limited slack between activities it will be unable to absorb variability in production. Interdependencies between contractors cause delays and conflicts to be transmitted from one contractor to another. The result is decreased productivity and increased costs. A tight time schedule increases the number of hot spots leading to a more chaotic, complex and uncontrolled construction site. To catch up, the work needs to be even further accelerated resulting in even more hot spots. As shown accelerating work is cost full. This is supported by Thomas (2000) who, as a result of accelerated work, recorded a decreased productivity on 25%. Finally, strict time limits entail the workflow to be optimized under non-optimal conditions. Even though productivity seems to be increasing, productivity per man-hour is decreasing resulting in increased cost.

Still too much time is not necessarily positive, because of a tendency in the industry to work best under pressure. Often extra time is wasted bringing productivity down. Extra time brings extra costs (Bromilow 1969; Walker 1994; Kenley 2001). To avid extra cost the deadline should be realistic, negotiable and flexibility in both directions.

The timeframe has to be set individually for every construction project where both internal and external costs must be taking into consideration. Therefore, as a general guidance, the timeframe should fit the individual project. But the deadline should be flexible instead of fixed. Negotiations between contractors and client should be in focus in a constant search for win/win situations. An increased focus on collaboration and negotiation between contractor and client will move the construction industry away from contract bonded projects. The results will be: decreased complexity, improved workflow, increased productivity, and increased value creation.

The second thing to mention is value. According to the Lean philosophy we should try to increase costumer value. And time is a parameter which effects costumer value. Here delays would cause dissatisfaction. This also indicates that the timeframe needs to be realistic. However, according to the interviews, quality is not noticeable affected by a tight schedule. The contractor still has to fulfill the contract.

Therefore, (s)he has a fixed quality agreement which may not be compromised when accelerating the work.

The tight schedule also affects the site managers. This sometimes results in too fast and not thought through decisions. This tendency is supported by Wantanakorn et al. (1999). But by involving the contractors who are affected by the decision and collaboratively find a solution most poor decisions are eliminated.

CONCLUSION

Through interviews with site managers and by looking into theory the effects of an extended timeframe was examined. It was found that a too tight schedule leads to conflicts and increased cost, while a too loose schedule often resulted in an unnecessary waste of time which also resulted in increased cost. The conclusion is that the time frame has to be realistic but flexible. Therefore, the time frame needs to be determined individually for every construction project. By introducing flexibility into the timeframe negotiations between contractor and client should help creating win/win situations in the attempt to bring both productivity and value creation up.

By creation win/win situations project cost will decrease. When negotiating win/win situations both internal and external costs should be taking into account. In relation to costumer value, it is important that the agreed schedule is realistic and obeyed. Delays and non-met agreements will decrease customer satisfaction and thereby decreasing the value creation.

Finally, the relationship between extra time and the T-F-V theory was considered. In the T-F-V theory time is considered waste. Even though extra time overall might have a positive effect on productivity and cost. Therefore, a more nuanced picture of time is needed. Even though time is waste wisely determined extra time can be necessary waste in the road to excellence in construction. Furthermore, extra time will increase the robustness of the schedule.

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