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COMPARING DIFFERENT APPROACHES TO SITE ORGANIZATION AND LOGISTICS: MULTIPLE CASE STUDIES

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ABSTRACT

Effective site organization and logistics is required to have an efficient production in construction projects. The same applies to the oil industry; it is absolutely necessary that the conditions are right for achieving efficient production. The oil industry and the construction industry operate under different circumstances, and have gained different experiences regarding the challenges of site organization and logistics.

Four different cases from four different firms are presented in the paper. One case is from an offshore drilling contractor in Norway. Two cases are from the Norwegian Construction industry. The last case is from a Swedish consultancy firm, specializing in site organization and logistics in the construction industry.

The case studies focus on how the different firms manage site organization and logistics to achieve an efficient production. Practices from both industries, and a generic list of lessons learned that is applicable to all construction projects are presented in the final section of the paper.

KEYWORDS

Lean construction, site organization, logistics, oil industry, construction industry.

INTRODUCTION

There are indications that the degree of innovation and the productivity growth rate has, since the mid-1990s, been lower in construction than in other industries (Produktivitetskommisjonen, 2015). Several other reports support the notion that the construction industry is lagging behind other industries in regards to productivity and reduction of waste (Koskela, 2000; Elfving, Ballard and Talvitie, 2010). Consequently, the decline in profit margins and increased competition in construction projects, forces the construction contractors to develop new ways of eliminating waste and increasing profit (Mastroianni and Abdelhamid, 2003).

Logistics to, and within, the construction site is an area with a particularly large room for improvement. A report by the Strategic Forum for Construction and

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Construction Products Association (2005) in the UK, estimates that based on evidence from other industries, cost savings of 10-30% can be achieved through effective application of logistics management techniques.

Although space needs and activity scheduling are mutually dependent, they are often considered separately (Zouein and Tommelein, 2001). Their interdependence is often ignored in the planning phase and may not be dealt with until construction is underway. Unforeseen problems identified late in the process are often expensive to remedy and can in many cases be avoided if considered at an earlier point in time. This indicates that there is a huge potential in the improvement of logistics and site organization.

In recent years, there have been several research papers addressing supply chain management (e.g. Arbulu and Ballard, 2004; Pinho, Telhada and Carvalho, 2008; Elfving and Ballard, 2013). These have focused on the flow of goods into the construction site. However, in the literature search for this paper, we found little recent research on the topic of site organization and logistics. Except for some papers that look at specific space planning tools (Tommelein and Zouein, 1993), there has been given little attention to the internal management of construction materials on site.

The paper aims to uncover effective and efficient practice for site organization and logistics on construction projects. This is done by studying three cases from the Scandinavian construction industry, where different approaches are employed. Furthermore, we also study a case from the oil and gas industry. This industry faces challenges in regards to operating in a large geographical area, while the worksites (the oilrig) are very confined. This makes an effective logistics scheme, and a carefully planned site layout, crucial for efficient production.

METHODOLGY

Construction logistics and site organization can be viewed as a result of project participants' decisions made in order to support the production. To get an in-depth understanding of this thought-process, we chose to conduct multiple case studies. Case studies are a qualitative research method that is well suited for digging deeper and gaining concrete, context-dependent knowledge (Flyvbjerg, 2006).

Projects with varying characteristics and executed by dissimilar companies were chosen. This ensured exposure to a wide variety of practices. While conducting the case studies a process of triangulation was employed. This implies using several sources of evidence to corroborate the findings in the case studies (Yin, 2013).

Semi-structured open-ended interviews were the main source of evidence in all of the cases. It was chosen to start the interviews by asking open-ended questions to avoid pointing the interviewees in a specific direction. However, a structured interview guide was also used to not leave out important aspects. By interviewing foremen, construction managers and project managers, different perspectives were accounted for.

The case studies are presented as narratives, allowing the reader to make their own interpretations. However, the main findings of the cases are summarized and discussed in the last section of the paper. Furthermore, documents such as site plans and procedures were reviewed. The last source of evidence was physical observations made by conducting site visits. The research methodology was the same in all of the case studies and the interviewees were asked identical questions to avoid bias.

RESULTS

CASE 1: HERSLETH ENTREPRENØR AS

The first case was the construction of a residential facility by Hersleth Entreprenør AS, a small Norwegian contractor. It was a design-build project with a value of 72.6 million NOK.

The forward planning was conducted in the design phase. Hersleth combined the role of design manager and project manager. This person planned the activities in a timeframe of 3-4 months prior to field execution. The production manager and foreman made a detailed activity plan, 1-2 weeks prior to field execution.

The layout of the site was planned in the design phase and remained the same for the entire construction period. The goal was to find a feasible and cost efficient layout while having easy access to water, sewage and electricity. The planned road and parking lot for the finished project was established early in the process, so that the construction work could take advantage of them. Therefore, trucks had access to the whole perimeter of the site, and could easily make deliveries exactly where the materials were needed.

Experience and routine from earlier projects was emphasized as the management's greatest asset in the planning phase. Most of the planning was done based on how it had been done on other projects. Hersleth did not operate with a separate order-schedule, but the orders were manually tracked and closely linked to the main progress-schedule. The contractor used construction drawings in an early phase to be able to order materials with a long lead-time, such as elevators.

The materials were delivered before the planned start of installation and stored temporarily on site. Efforts were made to store materials unexposed to the elements. Materials such as drywall and plywood were typically hoisted into the building per floor before the next level was added.

Hersleth had chosen to not rent a stationary crane. All of the larger lifts on the projects were related to pre-fabricated elements. These were all purchased with contracts that included delivery and installation. The supplier was also responsible for providing the crane, and brought a mobile crane on site as needed. This allowed Hersleth to carry out the remaining lifting operations at the site using only a truck-mounted crane. This was deemed the most cost efficient solution for this project.

Small make-to-stock (MTS) products, such as screws, nuts, bolts and personal protection equipment was delivered by one supplier. To avoid having to place several orders for these MTS products, vendor-managed-inventory (VMI) was implemented. The inventory of the "satellite store" was decided by the foreman and stocked once a week by a representative from the supplier.

CASE 2: VEIDEKKE ENTREPRENØR AS

The second case was the construction of a new high school. This was a public-private-partnership project with a budget of 765 million NOK. Veidekke Entreprenør AS, one of the largest general contractors in Scandinavia, was responsible for both the planning, design and construction phase.

Veidekke operates by their framework for project-based production, Collaborative Construction Management (CCM). This is an adaptation of The Last Planner System that has been used by Veidekke since 2006 (Fundli and Drevland, 2014). Site layout and logistics is an aspect of the CCM framework and is considered on all levels of planning. An overall plan for the site layout and logistics is made as early as in the design phase. However, this plan is of a dynamic character and is updated according to the production phases of the project.

When Veidekke planned the site layout for the project, they divided the construction period into six phases with six corresponding phase plans. The access road to the site and the crane, were placed so that they would avoid coming in conflict with the safety and operation of the old high school. The construction of the building was also done in such a sequence that materials could flow within the construction site without having to establish more than one access road. This was done by delaying the construction of the center of the building to allow trucks to access the back of the building through here, driving across the foundation.

Veidekke had a schedule for ordering materials, which gave information on what had to be ordered, when, and by whom. This allowed them to always be aware of lead times and critical dates. The material supplier delivered MTS items such as plywood, drywall, and steel twice a week on “milk routes”. This made it important to plan ahead, to avoid having to pay the additional cost express delivery would entail. Like Hersleth, Veidekke also employed VMI. The inventory of the “satellite store” was decided according to the phase the project was in and was stocked once a week.

To avoid congestion at the gate, caused by several deliveries arriving at the same time, they had a list with time-slots for deliveries that the trades could reserve. This was meant for deliveries that would utilize resources such as the crane or other lifting equipment.

The construction office and worker accommodations were located outside the construction site. This made receiving visitors and minor deliveries easier, as they did not have to conform to the site’s safety regulations. The minor deliveries were received outside the construction fence in a designated area.

The project management tried to get materials delivered only when they were needed – just-in-time. This was to avoid materials being in the way, taking up space and risk being damaged. However, materials such as drywall and steel were laid down on one level before the next level was added. This was done to make the lifting operations easier. Smaller materials and equipment had to be transported up the staircase by the work crews.

CASE 3: SVENSK BYGGLOGISTIK AB

Unlike the first two cases the third case does not revolve around a specific construction project nor a contractor. Rather, Bygglogistik AB acts as a third party consultant, providing logistics and material handling services for construction projects. The company builds its consulting business around a comprehensive logistics analysis. This analysis considers the parameters of the construction site and its surroundings while developing the logistics plan. The layout of the workplace and understanding how the contractor will execute the construction process is essential in the analysis. Logistics in all of the project phases, such as site preparation, framework and interior work, should be taken under consideration in an early phase. Bygglogistik emphasizes the importance of early involvement of foremen to get input on solutions that are both practical and efficient.

Bygglogistik conducts the logistics analysis using AutoCad, with additional embedded symbols and shapes. This allows them to evaluate different solutions. For example, by inserting crane radiuses they can find the optimal size, number and location of crane. The consultants also consider several other aspects regarding the crane location, such as establishing- and decommissioning-cost.

The logistics analysis is divided in two separate parts: the outer and inner analysis. Both the inner and outer analysis recognizes that the parameters of the construction site is dynamic and will therefore result in a dynamic logistics plan.

The outer analysis highlights the parameters for the construction site and the relationship to its surroundings. In other words, this analysis uncovers the possibilities and limitations that are present on the site and in the vicinity. Early planning gives the opportunity to take advantage of the area's possibilities, and mitigate the negative impacts of the area's limitations. For instance, renting space close to the site can be a good solution if there is not enough space for a laydown yard. The outer analysis must also consider disturbance to surrounding neighbors. It also considers the optimal placement of all necessary equipment to make material handling as efficient as possible. This can be visualized in a 3D-model as shown in *Figure 1*. The allocation of storage space for the various contractors is also a result of this analysis.

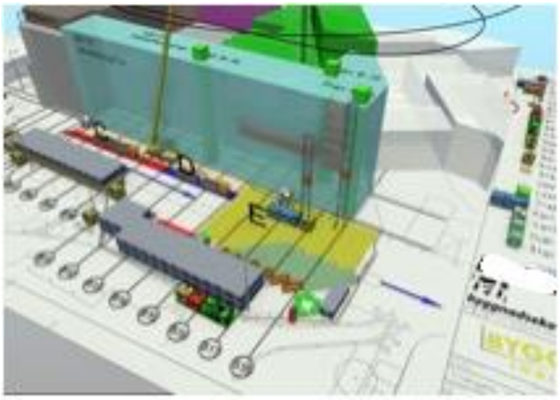

Figure 1. 3D Logistics Analysis

The inner analysis considers the flow of material from when they reach the gates of the construction site, until the final point of installation. According to Bygglogistik, aspects that are not taken into account in the planning phase can cause major added costs at a later stage in the project. Therefore, it is important to take into account both the size of the materials and the turning radius of delivery equipment. One example of a result from this analysis is to decide to design pre-fabricated elements with temporary openings to allow internal transportation of materials. Figure 2 shows a project where it was originally planned to use several construction elevators. By having temporary openings, only one elevator was required. Solutions like this can provide large cost savings.

Bygglogistik stresses early consideration of material handling. It gives them the possibility to impose certain delivery and packaging requirements on suppliers. For instance, less efficient packing results in the workers having to spend unnecessary time sorting, unpacking and distributing the windows. The window supplier can be required to package the windows on separate pallets for each apartment and in way that facilitates unpacking. This is usually no problem to arrange, if the request is made before making a purchase. However, this can be costly to arrange when the deal is done.

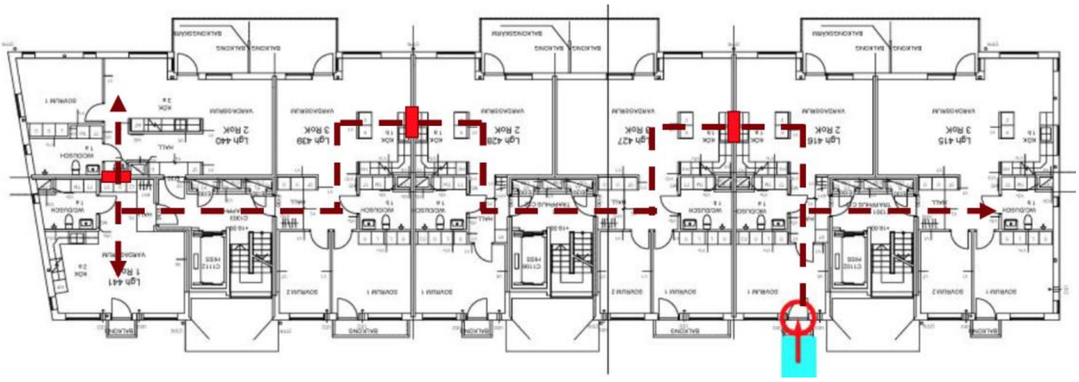

Figure 2. Design of temporary openings

Logistics Patrol is another service offered by Bygglogistik. This service comprises of the transport of materials into the building, and debris out of the building, after regular work hours. This means that the construction workers can focus on their trades, not performing material handling, and that the production will not be interrupted by material deliveries. Bygglogistik focuses on carrying out the work as economically as possible so that the customer will benefit. After finishing the job, the patrol creates a report informing of what has been done, and any damage occurred during delivery from the factory or occurred during the internal handling at the construction site.

Bygglogistik has developed a web-based software called LogNet for managing deliveries to the construction site. LogNet schedules the deliveries and provides a real time update of when they are arriving at the site. All users with access are able to check which unloading resources are available in a given time period. Everyone who is responsible for ordering materials to the site have access to this tool, and have to apply for a time-slot for their delivery. The time-slot has to be booked at least five days in advance. The administrator, usually the logistics manager, has to consider if the required resources are available. Based on the availability, the request is either accepted or a new time-slot is suggested.

All deliveries must be called-in by the driver 30 minutes prior to arrival at the construction site. When the materials arrive at the site the logistic manager will register them, and the responsible person will be notified by receiving a text message from LogNet. The materials will then either be picked up by the contractor or temporarily stored until the Logistics Patrol arrives in the afternoon. The logistics manager has a standby system with a dedicated parking area for delayed deliveries, and accepts the deliveries when the handling resources become available.

Bygglogistik was hired as a consultant and responsible for material handling in a residential project in Gothenburg with 162 apartments. The contract value of the project t was 160 million SEK. The marketing manager stated that the total achieved savings due to working efficiently with logistics was 16,000 working hours compared to what was estimated in the tender agreement. The total savings incurred for the project amounted to approximately 5.6 million SEK. The consulting and material handling cost for using Bygglogistik was approximately 2 million SEK. Total cost savings incurred by the developer was thus 3.6 million SEK.

CASE 4: SONGA OFFSHORE

The last case is from the oil and gas industry. Songa Offshore is a Norwegian drilling contractor founded in 2005. The company presently operates a fleet of three midwater semi-submersibles, but an additional four are being built and will be delivered within 2015. Songa Offshore is Statoil's largest drilling services provider operating in the harsh environment of the North Atlantic Basin (Songa Offshore, 2013).

One of the major challenges in regards to logistics in the offshore oil industry is the distance from the material supplier to the location of the oilrigs. The harsh weather conditions are also a factor that has to be considered. Scarcity of storage space on the oilrigs, long lead times on material orders, and large distances makes an effective logistics system a necessity to achieve efficient operations. Material handling onboard the oilrig is also a major challenge, and a field where there is great potential for improvement. One of our informants claimed that drilling for oil is about 90% logistics, making it extremely important to streamline this.

Many components that are crucial to the operations offshore have long lead times and it is therefore important to have spares, in addition to a buffer of consumables. While the most critical parts are stored on the oilrigs, most of the materials are stored at the base onshore. The base is also where deliveries from suppliers are made, repackaged and shipped offshore to the oilrigs. There is an advanced ERP-software in place, which comprises several functions, to keep up with maintenance needs. It alerts when maintenance is to be performed, produces a list of required materials, makes a work order request, orders the required materials and the transportation of them.

Limited space on the supply vessels, low frequency of shipments and weather conditions make forward planning and coordination with the operations team critical. If, for some reason, the necessary equipment has not been delivered on time, or spare parts are not readily available, the drilling contractor risks losing several hundred thousands of dollars in revenue. In such cases, the contractor goes to great lengths to get the parts. In some cases this even means chartering a helicopter to deliver a single piece of equipment. Therefore, there has to be a balance between just-in-time deliveries and buffers, being that the stakes are so high.

When supply vessels arrive at the rig, the deck crew operates offshore cranes to hoist the materials onboard. The containers are placed on deck according to where the materials are to be utilized and to optimize the deck space. The storekeeper makes sure that all the containers on the manifest are delivered, following a careful inspection and registration of the materials that have been delivered. Thereafter the person responsible for the order is informed that the materials have arrived.

The crew working on deck serves as a support function for the drilling crew, being responsible for all the logistics on the rig. Ideally they should have parts ready for delivery to the drill deck when they are needed. However, this isn't always the case. The ongoing operations on the drill deck is not very transparent, making it difficult for the deck crew to plan ahead and place materials in a logical manner according to drilling progress. This results in unnecessary material handling, which consumes resources in the form of labor and lifting equipment.

Based on decades of experience there has emerged a consensus viewing drilling operations as the handling and movement of parts and equipment. While the newer oilrigs are optimized for efficient material handling, the older rigs have several areas and rooms that are not accessible with crane, truck or elevators. The design of the new Cat-D rigs, which Songa has under construction, is tailored for efficient material handling. Flushed decks makes the entirety of it accessible with a forklift truck, and heavy equipment is moved on a tailored skidding system. Offshore cranes will handle heavy lifts on deck and to supply vessels, while elevators between the levels make the flow of materials within the rig more efficient. According to NORSOK Standard, “The installation shall be designed to ensure that the number of lifting operations is minimized” and “to facilitate use of fork lift truck or trolley, all transportation routes shall be planned without any obstructions or thresholds.” (Norwegian Standard, 2012) The goal is that this new rig design will be 20% more efficient than conventional rigs (Statoil, 2011).

Furthermore, there is great potential for developing and implementing software to streamline logistics and material handling. The idea is to utilize computer advanced visualization tools (CAVT) to make the needs of the drill crew more transparent. Because the drilling operation is planned in 15-30 minute intervals it is possible to also plan the logistics down to this level of detail. The crew on deck would then be able to place equipment strategically to effectively accommodate the drilling operations while optimizing space usage and minimizing lifting operations. Also, by virtually placing the equipment and parts on a 3D-layout of the rig, the crew is able to keep track of where the equipment is at all times.

DISCUSSION

In construction, materials are ordered, transported, delivered, stored, moved around, and processed before final installation. These steps should be made as efficient as possible. Steps such as moving and temporarily storing materials at the construction site are waste (Koskela, 2000), and should ideally be eliminated altogether.

Material handling within the construction site should be a priority on all projects. However, we found this to be lacking in some of the cases. Previously, in the oil and gas industry, this was barely a consideration while now it is one of the most important aspects of rig design and operations. Based on our observations, we believe the construction industry could potentially achieve great improvements in production. This will likely require that the efficient flow of materials within the site is considered far earlier on in the project than what now is typical. Solutions like the temporary opening in the pre-fabricated elements that we saw in the Bygglogistik case are only possible if they are considered as an integral part of the design process.

Planning the site layout, logistics, and allocating the proper resources are essential for an efficient production. There are clear differences in how these aspects are managed in the cases reviewed. Bygglogistik and Songa Offshore use ample resources to plan the layout of an effective production area. Hersleth seems to consider logistics as a field that can easily be managed using previous experience. We believe this business-as-usual attitude may limit the opportunities for improvement, and that a more structured approach, like the framework Veidekke performs by, is required.

The flow in production should never stop due to lack of materials. However, this does not mean that all materials should be ordered as early as possible and stored on site, but rather that they should arrive just-in-time on site. A balance between material buffers on site and just-in-time deliveries should be evaluated based on certain conditions: distance to supplier, lead time, level of detail in the plans, and amount of storage space on site. Buffers should be larger if these conditions does not favor the contractor. Naturally, there will need to be larger buffers on an oilrig offshore compared to a rural construction site.

All the companies had different approaches regarding the process of ordering materials. They all identified material requirements in the forward planning, but on different levels of accuracy. The cases with a structured delivery schedule with material lead times, critical order dates, and person responsible minimized the risk of forgetting materials. However, there is a clear potential for further improvement in the construction industry, by learning from the detailed planning done in the oil industry.

Delivery from material suppliers is another area of improvement, which can increase the efficiency. The delivery requirements for the material suppliers should be thought out and clear. Bygglogistik negotiates efficient delivery and packaging solutions during procurement to avoid having to pay an extra fee for this later in the construction process. This provides savings in terms of time and cost.

Implementing software can greatly contribute to managing logistics and creating transparency for stakeholders. LogNet, employed by Bygglogistik, is a good example of this. The software creates transparency for project participants by providing real-time information about when materials are arriving and which handling resources are at their disposal. Songa's idea for CAVT-software and their ERP-system is also a good example of software that contributes to efficient operations and production.

We believe that all projects could benefit from better management of logistics and site organization. However, it seems clear that the projects with difficult conditions like limited space, poor transparency and a congested environment will have a greater room for improvement. Hiring a company like Bygglogistik on a small rural project would likely be overkill, the cost would outweigh the benefits. On the other hand, using a structured approach, like the one employed by Bygglogistik, might be necessary for a large complex urban project.

CONCLUSION

Based on the findings from the cases, which are discussed above, it is clear that site organization and logistics is managed differently in the oil and gas industry compared to construction. It seems that the construction industry can learn from the oil industry in regards to managing their production as a flow of materials. Achieving efficient logistics to and within the worksite is a substantial contributor to efficient operations, which is also the case in the construction industry.

With regards to how site organization and logistics should be approached, there are four points that we found to be relevant to all projects:

- Site organization and logistics should be planned at an early stage
- Software tools are beneficial in managing site organization and logistics.
- A structured approach is necessary for optimal performance
- The approach has to be tailored based on project complexity

In this paper, we have barely scratched the surface on the topic of site organization and logistics in construction projects. Based on what we have found of literature on the topic and our findings from the cases, this is clearly an area that warrants more in-depth research in the future.

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