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REASONS FOR AN OPTIMIZED CONSTRUCTION LOGISTICS

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ABSTRACT

The claim of German builders is to realize individual and complex construction projects in the shortest possible design and construction time. Thereby the target achievement depends on a systematic and structured planning of the construction site and the associated construction sequences.

The construction logistics has the function to coordinate the core areas material, employees and information so that the correct material is available on a proper price, at the correct place, at the right time, in the exact quality and quantity, for the correct client (7 R's). Through the implementation of a superior, need-based coordination of the logistics, based on the required quantities, an efficient realization of buildings is feasible. Thus, time, quality and cost targets can be achieved.

Unclear is the question about the cost assumption for the site logistics. As for large-scale projects in Germany normally general contractors are assigned, they want to apportion the costs for the logistics to their subcontractors. Therefore, based on a practical example the trade-specific logistical effort is measured and characteristic values are generated. Based on these characteristic values the resulting logistical effort can be offset against the subcontractors. Through a lean logistics, also incentives for all parties are created.

KEYWORDS

Lean construction, logistics, value stream, work flow.

INTRODUCTION

Due to the ongoing individualization of products and additional industry-related challenges such as time and competitive pressures, lean production and business processes often become essential. This streamlining is also referred to as Lean Philosophy. However, the Lean-thoughts epitomize not only short-term single measures, but also a sustainable and long-term corporate philosophy. Recently, new combinations of notions such as Lean Production, Lean Thinking and Lean Logistics are gaining in importance and are summarized under the term Lean Management. Hence, Lean Management is an approach that transfers the Lean Philosophy to all business divisions and functions (Koskela, 1992).

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Whilst the subject Lean Construction is applied for many years successfully in the international construction industry, on German construction sites lean methods are used sporadically. The fundamental pursued objective is the optimization of the value streams. By using lean business processes, a continuous increase in power efficiency can be achieved. This efficiency is reflected in revised indicators such as cost, quality and delivery reliability and a higher process stability and reliability. Eying the building processes there is potential in the implementation phase especially in the field of the construction logistics (Kalsaas, et al., 2011).

In Germany, this can generally be attributed to the fact that each trade brings the required material or gets it delivered to the construction site based on their own planning. The consequences can be, among other things a late delivery of materials, delays in loading and unloading, unorganized storage and idle time due to a not terminated crane assignment This issue has been figures out almost 20 years ago by Bertelsen and Jorgen (1997), but nothing has changed in Germany until today. Instead, on German construction sites delays in the construction and thus interruptions in the value added chain are a daily occurrence. Leading to missed deadlines and rising costs.

The paper shows a way how on large construction sites in Germany, where often a general contractor with many subcontractors is used, the site logistics could work. A crucial role is played by a central managed site logistics, responsible for the implementation of the 7 R's of the logistics. How the occurring costs for the coordination and transportation can be allocated transparently and fair to the subcontractors is shown based on a practical example.

WASTE AND CONSTRUCTION LOGISTICS

WASTE

The guiding principle of Lean Management is the elimination of all types of waste. Waste (Muda) applies for all activities consuming resources without generating (additional) value of the product and consequently do not directly contribute to value creation (Womack and Jones, 2003). Ohno (1988) distinguishes seven types of “Muda”:

- Transport
- Inventories
- Movement
- Waiting
- Inappropriate Processing
- Over-Production
- Defects

The value of a product is divided into material and service. In large part, the value added of a product is generated within the production. The value added is defined as the difference between the value of a product before and after its manufacture. In logistics, the product undergoes usually no further transformation, but is merely transported and stored. Hence, the logistics is in line with the service

(Mossman, 2007). For the customer the value in logistics increases if the 7 R's of the logistic are observed (Silva and Cardoso, 1999). Those provide that

- the right product,
- with the right quantity,
- by the right quality,
- at the right time,
- at the right place,
- to the right costs and
- for the right costumer are supplied.

CONSTRUCTION LOGISTICS

An exceptionally wide range of transported goods characterizes the construction industry. The building site, which includes accommodations, scaffolding and equipment, represents the construction logistical starting point. During the actual construction phase the transport of building materials and construction operating supplies predominates. However at the same time, the disposal and recycling of construction waste and work equipment is an important factor.

The construction logistics comprehends in addition to the planning and execution also the steering, documentation and the monitoring of all project related flows with regard to materials, persons, working medium and information. Mossman (2007, p.199) states that “good logistics is concerned with how people, information, equipment as well as materials arrive at the workface able to create value in safety and comfort“.

Figure 1 illustrates that the construction logistics can be divided into the sectors: procurement logistics, site logistics, disposal logistics and information logistics.

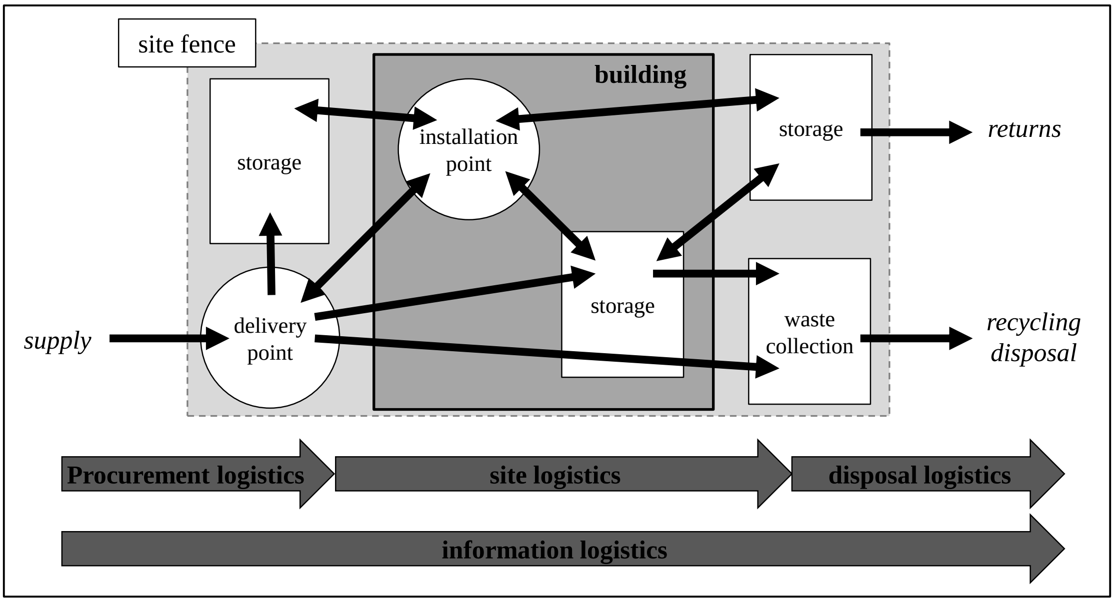

Figure 1: Sectors of the construction logistics (Figure 3 in Krauß, 2005)

The procurement logistics exclusively deals with the supply of goods and ends with the arrival of those goods on the construction site. As orientation guide for this purpose the construction border, which is normally the hoarding, can be used. Once the goods are on the site, all transportation and processes are assigned to the site logistics. This includes all transport-, handling- and storage-processes done with cranes, concrete pumps, lifts or forklifts until the objects arrive at their irrevocable installation point.

The differentiation between site logistics and disposal logistics can be done in a variety of ways. Depending on the view it is possible to have a separation already at the point of origin or not before the arrival of the waste at the collecting point on the construction site. In the context of disposal logistics, however, not only reutilization and removal processes of construction waste are considered. In addition to demolition waste, dredge spoil or packaging it covers also the removal of the site equipment.

The fourth sector is the information logistics. A coordinated, reliable and continuously flow of information is one of the main problems within the fragmented project handling (Girmscheid, 2010). Based on the logistical idea of a connection of information to other objects and consequently the impact on other transportation processes, the information logistics is classified as an important cross function. According to the current understanding of logistics the information logistics should not be limited to the objective flow of supply and waste removal but should cover a holistic view on the flows of information. Meaning also information flows from areas such as plan covering the project, scheduling, or building site are to be considered (Krauß, 2005).

PROBLEM AREAS AND TARGETS OF AN OPTIMIZED CONSTRUCTION LOGISTICS

PROBLEM AREAS

Arbulu and Ballard (2004, p.5) define that ‘‘variability is omnipresent in any production and supply system”. This finding illustrates a universal basic problem of the logistics. Therefore, a hundred percent reliable and smooth workflow is an utopian and unattainable notion of theory (Arbulu and Ballard, 2004). Within each production, the supply chain shows fundamental variances on the side of the provision as well as on the side of requirements. In the construction industry this subject is in particular distinct. As typical problems e.g. following issues can be mentioned:

- Missing or delayed deliveries.
- No direct unloading of transporters.
- Ineffective management of storage space.
- Installation of wrong and damaged material.
- No or insufficient separation of emerging waste.

The mentioned issues negatively affect in particular the productivity of a site (Elfving, Ballard and Talvitie, 2010). Numerous working hours studies yield that only a third of the total working time is used for the principal activity. Another thirty-three percent of the working time passes by for additional business and interruption that are essential and inevitable in providing the principal activity. To these belong recreation-related, workflow-related and individual-related interruptions. The remaining third of the working time is used for avoidable additional business and fault-related interruptions. All clean-up efforts and search processes as well as unnecessary covered distances and waiting time are reflected in this percentage. Only by using more than 50 percent of the working time for the principal activity a construction progress according to plan, without any serious loss of time, can be ensured (Berner, 1983). In order to increase the worker productivity of a construction site it is important to identify and eliminate the named weaknesses.

The illustrated shortfalls often have their seeds in the fundamental problem of an insufficient production planning. The successful realization of a construction project requires an accurate and extensive planning, which does not only include the set and project aims, but in particular the path to reach it. A construction-accompanying project planning often prohibits the planning of the path. Therefore, a consistent logistics understanding as well as an integrated overall logistic planning is extremely difficult to realize.

Furthermore, material flows are a coordinative challenge with high potential for optimization on large construction sites where different trades are working often in parallel.

Nevertheless, the production on the construction site depends on a variety of uncontrollable and unpredictable parameters. Weather, traffic accidents and strikes are only some examples for this purpose.

TARGETS OF AN OPTIMIZED CONSTRUCTION LOGISTICS

The guiding principle of an optimization of the construction logistics is to eliminate the exemplified problem areas. With the help of a logistics management efficient and effective logistic processes should be created. In the ideal case all non-value adding activities and accompanied costs are reduced to a minimum or can be even eliminated completely. This development conforms to the principle of the Lean Philosophy. The goal is to slim down all business processes within a company and to boost consequently the value added.

In order to achieve those objective targets, the construction logistics has to fulfil different tasks. They can be deviated with the help of the overall 7 R-rule. For the site logistics this means to provide the

- correct inventories, hand tools or materials,
- at the installation point,
- at the right time,
- in the right quantity,
- and in the right quality,
- for the right subcontractor
- as well as for the proper costs.

The realization requires a detailed planning of all supply and waste disposal processes as well as of all transport-, handling- and storage-processes.

Hence, a stage of construction and trade related coordination with regard to timing for the consumption rate and the necessary supply and waste disposal capacities is required. For this purpose all required consumption rates and quantity delivered as well as the exact point of time have to be registered in time for the respective stage of construction. Based on the registration the delivery time slot is checked. As test criteria among others, the capacity of storage and dumping grounds as well as the capacity of lifts and cranes are consulted. Nowadays, registration, checking and approval are usually done via digital coordination platforms. The illustrated factors can be summarized in some overall and transferable principles for the construction logistics (Girmscheid, 2011):

- Early registration and coordination of deliveries.
- Prevent inefficiency because of parallel work at one place.
- Plan transportation routes and storage rooms for each construction phase and stage of construction.
- Avoidance of material rearrangement.
- Order and cleanliness at the construction site.
- Protection of stored materials and worked construction performances against any kind of damage.
- Keep trails free for supply and waste disposal purposes.
- Minimization of storage room by better coordination of storage and Just in Time deliveries.
- etc.

CHANCE FOR THE OPTIMIZATION OF THE SITE LOGISTICS IN GERMANY

The production planning provides the basis for an accurate planning and provision of trade-specific required materials. As the planning often occurs simultaneously to the construction progress such a foundation is a general problem in Germany and Just-in-Time deliveries are made almost impossible. Aggravating this situation, the different subcontractors are having their own planning on the basis of which they deliver their materials to the construction site. These aspects are reflected in an unorganized storage. An opportunity to still reach a continuous flow of materials according to the lean principles is a centralized logistic management, which verifies, coordinates and carries out all site logistics material and information flows.

The activities of the logistician can be separated into different super ordinate main sections. Thus, his fields of activities are the already named procurement, site and disposal logistics. Furthermore all these aspects are accompanied with an automatic information logistics. The pursued objective is to create optimized working conditions for all parties involved. Due to the timely planning and coordination of all transports, a smooth and continuous construction process without any uncoordinated deliveries or temporary storages is ensured. Also the existing building site equipment isn't overextended. Another advantage is that downstream trades are able to focus on their principal activities.

Besides these positive effects it is necessary to consider, that large-scale projects in Germany are normally implemented by general contractors, who are primarily in charge of the additional costs for the engaged logistician. Hence, they strive to pass on all these costs to the different subcontractors. In Germany the cost allocation is usually calculated with a fixed rate of 2 - 3% on the subcontractor's contract value.

Since there are no evidences or reference values with regard to the trade-specific logistic efforts so far, it is necessary to determine such specific values. On the basis of these values the costs incurred can be allocated transparently to the subcontractors and additional incentives for a needs-based logistics are provided.

The system of such a construction logistics concept will be demonstrated in the following practical example. Specific values will be generated to determine and allocate the trade-specific logistic costs properly.

The practical example is a new office building in Germany with a total cubical content of about 220.000 cbm and a gross floor area of nearly 50.000 sqm. Due to these figures the example can be categorised as a large-scale project. The construction proves is implemented by a general contractor who is applying lean construction methods. The agreed allocation for logistic costs is 2 % of each contract value. This amount includes the time as well as the machines that are required.

For the generation of the trade-specific characteristic values the logistics company was attended on several material handlings. The focus of the investigation was on deliveries from the supplier’s central store to the point of installation. Three trades with high logistical effort caused by the weight or dimensions of the materials were analyzed:

- Cavity floor
- Plasterboard
- System partition walls

During the data collection it appeared that the used number of cranes, goods lifts, lorries, etc. was for all trades comparable. Therefore this aspect was no longer taken into consideration. According to this the specific values are based on the number of deployed workers, the individual scope of delivery, as well as the time scope. In fact of differing numbers of deployed workers and time scopes the accompanied delivery procedure was separated into the two processes ‘unloading’ and ’move’.

As presented in Table 1, the generated specific values (column 3) seem very short. But if the scope of work (column 4) is taken into consideration the supposed short time periods are summed up to huge amounts. For example the 28.000 sqm of cavity floor are causing a logistics effort of almost 400 h (column 6). This logistics effort and the average hourly rate of 40 €/h result in trade-specific logistics costs of 15.916,99 € (column 8). The hourly rate of 40 € contains the use of a forklift operator, including the machine, as well as other workers, who are engaged to move the material. By means of the total logistics costs (column 8) it is clearly evident, that the accruing logistic arrangements are causing a huge and significant time and cost factor, even if the determined figures seem very short in the beginning. Furthermore Table 1 shows that the application of a fixed rate for the cost allocation (column 10) does not reflect the reality. Therefore appropriate and individual cost allocations have been determined (column 11). Against all expectations the costs for material handlings of the trades ‘cavity floor’ and ‘plasterboard’ are below 2 %. In contrast the agreed cost allocation for the trade ‘system partition walls’ is too low (column 12).

Table 1: Trade-specific characteristic values from general contractor's side of view

1	2	3	4	5	6
trade	**specific values**		**scope of work**	**logistics effort**	
	process[h/sqm]		**[sqm]**	**[hh:mm:ss]**	**[h]**
cavity floor	unloading	00:00:05	28.000,00	41:31:18	41,52
	move	00:00:46		356:24:10	356,40
	∑	00:00:51		397:55:29	397,92
plaster board	unloading	00:00:03	20.000,00	16:57:44	16,96
	move	00:00:33		184:24:11	184,40
	∑	00:00:36		201:21:55	201,37
system partition walls	unloading	00:00:32	5.000,00	44:38:43	44,65
	move	00:07:10		596:41:22	596,69
	∑	00:07:42		641:20:05	641,33

	7	8	9	10	11	12
	logistics costs	**total logistics costs**	**contract value**	**agreed cost alloc.**	**actual cost alloc.**	**Δ cost alloc.**
	[€/h]	**[€]**	**[€]**	**[%]**	**[%]**	**[%]**
cavity floor	40	15.917	960.000	2,00%	1,66%	0,34%
plaster board	40	8.055	790.000	2,00%	1,02%	0,98%
system partition walls	40	25.653	795.000	2,00%	3,23%	-1,23%

The generated characteristic values can be used as an indication for the allocation of the logistics costs. However it is important to note that the logistical effort depends on the project type and that the characteristic values are transferable only in some degree. Moreover it is important to take the other sections of procurement and disposal logistics into consideration and to analyse how far they contribute to the total logistics effort of the different trades.

CONCLUSION

The construction logistics plays a key function during the project realization phase. It coordinates the core areas material, staff and information so that the value chain for the construction of the building is not interrupted. Basis for smooth processes is a final production planning. Therefore, especially in Germany clients need to be sensitized with regard to this topic. Even if the assumption of a smooth building process is utopian in reality, the optimization of the site logistics can have a substantial impact on:

- Reduction of inventories on the site.
- Delivery of materials in time.
- Consistent workload of the cranes, goods lifts, etc.
- Avoidance of material search.
- Focus on principal activities.
- Higher workflow and thereby free capacity.
- Clear responsibilities and transparent execution of construction work.
- Clean and safe site.

Especially deliveries for trades with a high logistical effort can increase logistic costs enormously during the project realization. This is the case if there is no logistics company doing a centralized logistics but rather the subcontractor is responsible for the transportation, supply and disposal of the material. Nevertheless, also a decentralized logistics can be "lean", if the production planning is completed at an early stage and if it can be implemented in the logistics processes. In addition, all in the construction project involved companies should act according to the Lean principles. As this is in Germany currently rarely the case especially on large construction sites, the construction companies are forced by the client to implement Lean measures. Therefore, incentives to increase the acceptance have to be created. One possibility has been demonstrated on the basis of a practical example, where the costs allocated to the subcontractors have been broken up transparently. Another positive aspect is that the characteristic values can give information and starting points for further lean measures in the construction logistics.

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