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Just-In-Time Logistics in the Supply of Building Materials

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ABSTRACT

Normally building materials are transported to the building site as a part of the purchase, and the price quoted is 'as delivered in whole truckloads'. This tempts the purchase organization to save a few cents, which are easily lost by an unsuitably form of delivery.

Studies of logistics show that a substantial increase in productivity can be obtained by delivering building materials on conditions laid down by the construction site, i.e 'just in time' and 'packed for the work process'. The additional cost by this approach can easily be covered by the savings gained on the construction site.

This paper briefly describes the framework in which building logistics are seen, report the studies undertaken and explain the philosophy behind a series of tests carried out in practice to explore the idea further. Part of that has been to experiment with new ways of organizing the cooperation between the companies which are responsible for the final product - the house.

In the conclusion are given the experience drawn from the tests and some of the planning and control methods which have proved to be useful.
Key Words
building process productivity; logistics; just-in-time; materials management; partnering

Introduction

The building process is generally the result of a number of trade contractors' joint effort to erect a building never seen before. The process is often almost chaotic, even if the work is planned in accordance with best industry practice and unforeseen events are more the rule than the exception. Delivery of materials are seldom scheduled and manufacturers and wholesale dealers report that express delivery is by far the most commonly used form of delivery when counted by number of orders.

When looked upon with the eye of the manufacturing industry the major challenge for the building industry is obviously to create order and control in order to reduce costs through elimination of waste.

Even though this paper presents a concept and a case from the Danish building industry the authors believe that the general description and the conclusions presented are valid in almost any country. The cost components of the construction price may however vary from country to country influencing the savings potential. In Denmark the typical building costs for a social housing scheme can be divided into: materials 50

percent, labour 30 percent, heavy equipment 5 percent and design, construction management, and supervision 15 percent.

Logistics in the manufacturing industry

Logistics, originally the 'Art of moving and quartering troops', are today a very important means to increase productivity and flexibility in any manufacturing industry. The manufacturing industry's logistics methods were originally developed primarily for the internal logistics, but with the increasing distribution of the manufacturing processes the focus today is as much on the external logistics and on the synchronization between the parties in the supply chain. Two different principles can be identified: logistics by planning (fi, Material Requirement Planning) and logistics by consumption. The main difference between the two is that by planning the foreseen consumption is calculated and materials ordered and delivered accordingly, whereas by consumption the storage is filled up when a certain minimum level is reached. For a number of years most logistics have been based on one of the two principles only. Today a two level approach seems to be preferred: a planning approach on the overall level and a consumption approach in the day-to-day operation.

A very special form of logistics by consumption is Just-In-Time (JIT) where minimum level before fill up is close to zero and the order size for the part in question is near one. At the same time emphasis is put on an overall planning carried out by the management combined with a day-to-day operation undertaken directly from the shop floor. The JIT logistics were developed by the Japanese automobile manufacturer system Toyota as an essential part of *The Toyota Production System.* The basis of this system is the absolute elimination of waste. The two pillars needed to support the system are: *Just-In-Time* and *Autonomation* (or *automation with a human touch).* Closer co-operation with the suppliers and a no error quality management system are important elements of the Toyota approach too (Ohno 1978).

It is these Toyota principles and primarily JIT - adapted for the building process with its one of a kind operation - that are used in the concept for the building process' JIT logistics - *Byggelogistik* - presented in this paper. And *Byggelogistik* aims as well as the Toyota production system at reduction of cost through absolute elimination of waste.

Logistics in the building process

The manufacturers' and wholesale dealers' logistics are very like the logistics of any manufacturing industry or wholesale trade. Indeed they are to be considered as belonging to such industries and to behave like such. If the contractors do not look out, their logistics too will be decided by the manufacturers and the traders, who will minimize the cost of transportation to the construction site without considering the following handling costs.

If on the other hand one looks upon today's logistics in the building process from the builders' point of view it is hard to find any strategy at all. As a matter of fact, the logistics far too often seem to be based on the Oops!-principle ie, ordering and deliveries take place when the production comes to a halt due to lack of the materials required. This means not only frequent delays and loss of time but also additional costs caused by express deliveries. Another strategy seems to be: 'get it as cheap as you can', an approach which is often favoured by Danish contractors' purchase departments because they are offered a price free of transportation costs if they buy by whole truckloads. As delivery of materials is seldom scheduled as part of the building process each delivery becomes an unforeseen event added to the general disorder. Besides this it means that a lot of materials are unnecessarily stored on the construction site, which is quite unsuitable for this kind of operation. The result is interruption of work, extra handling, breakage and loss, not to mention the requirement for not otherwise needed storage capacity. Thomas (1989) reports 200 lost work-hours out of a total of 1256 - or app. 16 percent on a structural steel erection job due to bad materials management, and Anderson (1983) mentions that 10 percent of the materials costs are caused by unforeseen events.

Also the direct costs associated with the transport of building materials are substantial. A Swedish analysis (Söderman, 1985) calculates the 'cost staircase' for a number of building materials, and finds that the total costs of transportation for some materials add up to more than one third of their total cost. This surprisingly high number is even higher when one includes the costs of handling processes unnecessarily undertaken on the construction site. As the materials count for 50 percent of the building costs, the total cost of transportation may be more than 10 percent of the net building costs excluding design (conf also Andersson 1983).

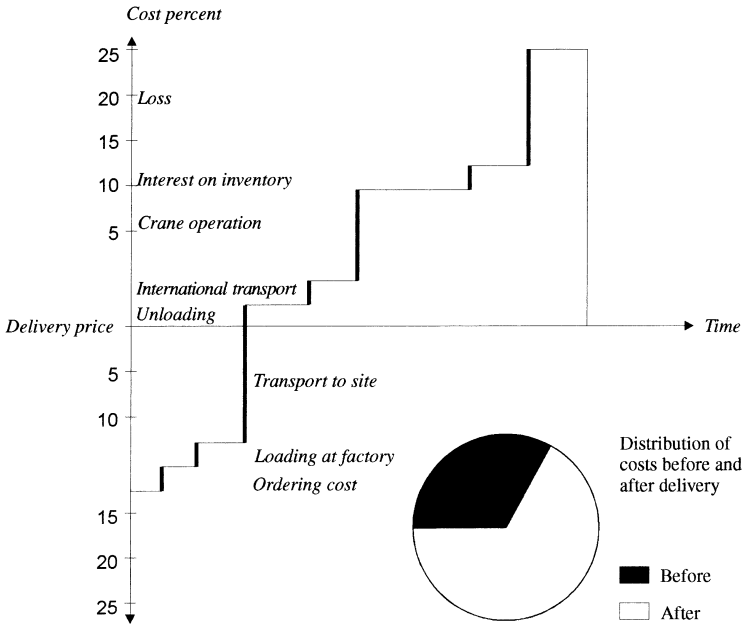

Figure 1 The cost staircase
Mineral wool for insulation (Södermann 1985, edited)

Materials management has in particular been studied in Sweden where a number of experiments have been undertaken (Andersson, 1983; Lindgren, 1985; Söderman, 1985). Like similar experiments and studies in other countries (fi Thomas 1989) it has primarily been as a means to reduce one or a few specific cost elements such as transportation to the construction site or inventory costs, or to ease a specific site operation, not making the total production process on the building site more efficient. Some theoretical studies on the approach are reported (Akintoye 1995; Low 1992), but no real life cases.

The *Byggelogistik* project reported in this paper was commenced in 1989 by a group of Danish companies from various branches within the industry who saw the savings potential in the JIT approach. The Danish Building Research Institute (SBI) joined the group in 1992 and the matter of building logistics was made a research area at the institute in 1994 (Clausen 1995). SBI has studied the increase of productivity in the *Byggelogistik* cases and made methods general.

The *Byggelogistik* project is primarily an experiment where a concept for a new and more efficient logistics for the entire building process has been developed and immediately tried out in practice as would be expected in an industry project. However, the project was started by a more theoretical study where the manufacturing industry logistics and the Swedish experiences were reviewed. Furthermore, a fairly systematic analysis of productivity losses on the building site with special attention to materials management was undertaken (Bertelsen 1993). This study also included interviews with different participants in the building process - not only architects, engineers and contractors but also manufacturers and wholesale dealers.

Nine symptoms of bad materials management were identified and each were further analyzed for the underlying causes. It was noted that the same causes were found again and again. In particular insufficient planning of the work and the deliveries, quantity discounts, errors in drawings and specifications and other human errors were found behind most of the symptoms. During this work it was recognized that there was a surprising shortage of management attention to this part of the building process, mainly due to lack of capacity. But it was also found that there were no practical tools for this kind of operation. Finally it was registered that there was no systematic feed back of experiences from the operations. Mistakes were repeated again and again. It was on the basis of these findings the *Byggelogistik* concept was developed.

The Building Logistic Concept

Table 1

Symptoms
Much internal transport
Storage on the building site
Great losses
Much pilfering
Lack of materials
Errors in deliveries
Plenty returned materials
Breakage
Damages upon work already made

(Bertelsen 1993)

Inspired by the Toyota Production System the aim of *Byggelogistik* is to reduce cost by eliminating waste of all kinds. Foremost waste of materials, but also waste of labour time and transportation. In this the *Byggelogistik* concept is an instrument for making the whole building process more effective.

The main objective is to look not only at direct transportation costs but at all costs in the building process related to materials delivery. Materials are not considered delivered until the workers lay their hands on them in the exact quantity as the first step in the construction. Packing, temporary storage, on site transportation, on site losses and breakage, and low effectiveness due to badly and impedingly delivered and stored materials are all considered as belonging to the transportation costs.

A Swedish study (Hammarlund 1989) has shown that approximately a third of the time used by the worker on the building site is spent procuring his materials in the widest sense, equalling about 10 percent of the total building cost. The hypothesis of *Byggelogistik* is that a near-optimum form of supply will increase costs only marginally, but will reduce waste of time considerably. This means that materials delivery in *Byggelogistik* is looked upon from the point of view of an optimum building process primarily.

Byggelogistik (Bertelsen 1994-1) makes use of a two level logistics with a planning approach for the over all logistics and a JIT consumption approach for the daily deliveries. The logistics are considered already on the drawing board. Materials are, where it is possible, specified as belonging to the separate building operation during the detailed design. In the planning of the operations all supplies are described in detail aiming at JIT ie, supply once a day, comprising only materials needed until the next day, and packed for the various trades and their individual tasks and work areas. Such assemblies of materials are named 'units'. Each type of unit is carefully specified to include all materials needed for the particular task, and form of packing as well as equipment for the delivery is detailed. Each type of unit is given a specific number for identification. Several participants in the project consider the unit the most original element in the whole concept. The idea is taken from the Swedish furniture chain Ikea who sells furniture in parts to be assembled by the customer but with all the parts - and often tools and assembly instructions - in the same box.

In order to manage sorting, packing and delivery a close co-operation with the wholesale dealers must be established. In Denmark 3 kinds of dealers cover all necessary materials, and their warehouses are used as store room for the building site. A few kind of materials are delivered directly in units packed by the manufacturer, but most materials are delivered to the warehouse to be sorted and packed in units, ready for transportation as the work progresses. In order to reduce the costs of external transportation joint deliveries are used containing all units from the dealer regardless of contractor, and to minimize internal transportation delivery of units takes place as close to the work area as possible. The dealers' drivers are considered as part of the building team in as much as the aim is to employ the same drivers to load the trucks and deliver the materials every day thereby making them familiar with the ever changing lay out of the building site and choose the best sequence for the unloading.

Byggelogistik is characterized by careful planning, daily management executed from the building site - not the head office - and immediate and direct feed back of all mistakes.

Careful planning demands that detailed design is fully completed before the building process is started, in order that all materials may be counted and specified in units. In this way delivery schedules on a weekly basis may be worked out right from the start, covering the entire building period, and all

materials may be ordered bindingly. Planning must take place in close co-operation between designers and trade contractors, and the wholesale dealer's employees should take part in this. Tests have shown that this kind of co-operation has resulted in a good deal of suggestions for more appropriate solutions and choice of materials. At the same time better terms for delivery are obtained since favourable prices may be offered by the producers due to early notice.

Besides the close daily management mid-weekly meetings should be kept where the progress is considered and where tasks for the next 3 weeks are established. Then requests for units can be worked out, specified by working days for the first 2 weeks, and stated in total for the 3rd week. These requests are sent to the wholesale dealers as a final request for the first week and a notice for the next 2 weeks.

UNITS

Job: SOPHIEHAVEN
1. phase

Unit no. : T001
Name : Sloping beams
Total number : 10
Place in building :
Supplier : Brdr. Bendtzen A/S
User : Carpenter and joiner contract

Page no 1 of 1

Date: 10 May 1991
Rev.date: 21 June 1991

Part ID	Name	Number	Unit
0005	Wall plate 25x100 DF, pressure-treated 270cm	2.0	pieces
0006	Wall plate 25x100 DF, pressure-treated 360cm	6.0	pieces
0007	Wallplate 25x100 DF, pressure-treated 390cm	14.0	pieces
0008	Wall plate 25x100 DF, pressure-treated 420cm	4.0	pieces
0011	Cross Bracing 25x100 DF, 300cm	4.0	pieces
0013	Cross Bracing 25x100 DF, 360cm	10.0	pieces
0014	Cross Bracing 25x100 DF, 570cm	8.0	pieces
0020	Construction trestle 25x100 DF, 450cm	14.0	pieces
0021	Construction trestle 25x100 DF, 480cm	7.0	pieces
0022	Construction trestle 25x100 DF, 570cm	49.0	pieces

Information on delivery
Weeks request : 1 week
Form of delivery : Lorry with crane
Unloading : Crane
Packing :
Return packing :
Remarks:

Figure 2 Unit specification

DELIVERY SCHEDULE

Job: SOPHIEHAVEN
1. phase

Supplyer : Superbyg
Effective for : Weeks # 27-45
Block no :

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Date: 20 May 1991
Rev.date:

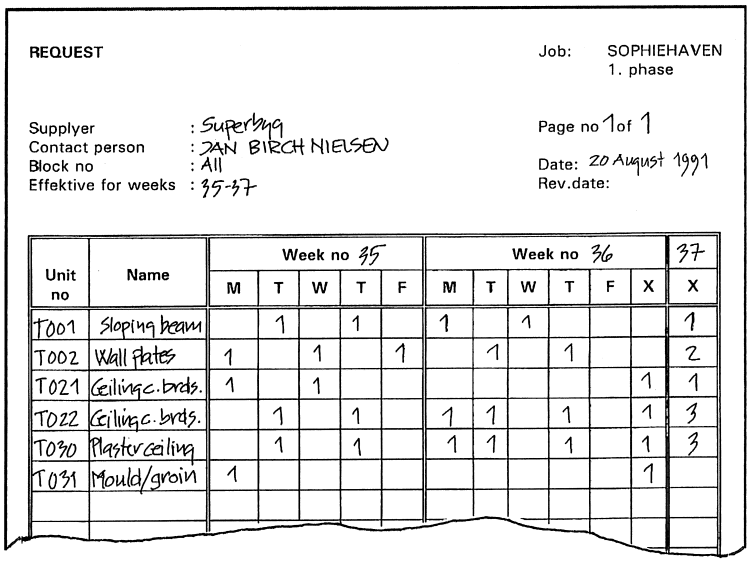
Week no

Unit no	Name	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
T001	Sloping beam					1	2	1	1	2	2	1								
T002	Wall plates								1	3	2	2	2	2						
T021	Ceiling c. boards							1		1	1	1	1		1		1			
T022	Ceiling c. boards								1	3	3	3	3	3	3	3	3	3	2	1
T030	Plaster ceiling								1	3	3	3	3	3	3	3	3	3	2	1
T031	Mould/groin				1		1		1		1									

Figure 3 Delivery plan

An immediate feed back of all mistakes must be established. All deliveries should be carefully inspected upon receipt and all irregularities carefully noted. Even a label upside down or a spelling mistake must be registered. Gross blunders must be reported back immediately to the parties involved, and all irregularities gathered in a weekly report distributed to all participants in the logistics scheme. This close and systematic reporting - in a civil tone - contributes towards immediately improving the performance of the companies involved. Nobody likes to have their mistakes pointed out in public.

A special manager of logistics - a *provider* - must be appointed to run the entire operation as part of the construction management on site. To ensure the engagement of the companies involved and their employees, a steering committee should be established comprising senior management representatives from these companies. The steering committee surveys the process and solves the conflicts that inevitably occur and they note the productivity gains.



REQUEST

Job: SOPHIEHAVEN
1. phase

Supplyer : Superbyg
Contact person : JAN BIRCH NIELSEN
Block no : All
Effektive for weeks : 35-37

Page no 1 of 1
Date: 20 August 1991
Rev.date:

Unit no	Name	Week no 35					Week no 36						37
		M	T	W	T	F	M	T	W	T	F	X	X
T001	Sloping beam		1		1		1		1				1
T002	Wall plates	1		1		1		1		1			2
T021	Ceiling c. brds.	1		1								1	1
T022	Ceiling c. brds.		1		1		1	1		1		1	3
T030	Plaster ceiling		1		1		1	1		1		1	3
T031	Mould/groin	1										1	

Figure 4 Weekly request

Sophiehaven etc

Up till now *Byggelogistik* has been tested on six housing schemes, the first being *Sophiehaven* approximately 20 miles north of Copenhagen. The project is a typical Danish social housing project comprising 100 flats in two stories blocks, erected in two phases - not a big project on an international scale (Bertelsen 1993, 1994-1, 1994-2).

Contractually the project was undertaken by a general contractor and approximately 10 trade contractors. The general contractor's staff participated in the whole planning of the project. It was also from the staff of the general contactor that the provider was recruited and his job developed, as the project progressed, into being the production manager of the construction site. He planned the day-to-day operations, he provided the materials required, he coordinated the individual trade contractors' works and he followed up on the co-operation with the wholesale dealers.

In order not to overreach the experiment in the first phase it was decided to restrict the logistics to a minor number of the trades. This decision caused a great deal of trouble. Those not participating were repeatedly in the way of those who were. In the second phase all trades participated and this problem was solved.

Even though the methods were developed with EDP in mind the first tests were restricted to management by paper and pencil only. EDP was used in the usual manner in the participants' own operations but no attempt was made to use IT in the logistics.

To supervise and control the process a steering committee was established as laid down in the concept. As the project more and more came to resemble a partnering project, this committee undertook the role others have learned to be indispensable in any such project.

The results were surprising. Everywhere reductions in the materials consumptions were immediately registered at the same time as productivity and quality increased. A higher degree of workers' safety on the construction site and a much higher morale among all participating workers, foremen and contractors was noticed as well.

In the building industry the difference between calculation and actual consumption from job to job often goes up as high as ? 5 percent, making improvements in the productivity of the same order hard to measure. It was therefore necessary to look at other indicators than just the actual consumptions. It was obvious that the work progressed much faster than expected, that several trade contractors had too many workers on the site and that the performance-based wages of the workers became unusually high.

Table 2

Symptoms	Observed in experiment
Much internal transport	Little internal transport
Storage on the building site	Almost no storage at all
Great losses	Losses counted into few single items
Much pilfering	No losses due to pilfering
Lack of materials	No express deliveries at all
Errors in deliveries	A few errors but much less significant and mostly correct at the next delivery
Plenty returned materials	Almost no returned materials
Breakage	A few but much less than usual
Damages upon work already made	Almost avoided

(Bertelsen 1993)

It was estimated by the participants and the Danish Building Research Institute that the total savings in the second phase - where the system was fully operationable - was 9 percent of the net building costs, divided into 18 percent on the labour costs and 3.6 percent on the materials (Bertelsen 1994-1).

The savings were not equally distributed and no attempt was made to redistribute costs and savings between the participants. It was therefore interesting to notice that even those participants who were expected to make a bigger effort than usual observed no additional costs but often found unexpected savings. Saved rush orders, fewer mistakes, easier construction management and quiet operations more than made up for planning, repacking and mixed transport.

Even though *Sophiehaven* was a clear success the results of the following tests have been more mixed. In the worst case there was no increase in productivity at all, but fortunately this was a sole event. Most cases show improvements from 50 percent of those from *Sophiehaven* up to improvements of the same size. The reason for not obtaining the same improvement - or a steadily growing improvement as a manufacturing industry would expect - is probably inefficient management of the experiment or a steering committee not paying adequate attention to the experiment which again causes lack of motivation by the participating personnel and make the participants fall back into their usual thinking and acting, leading into sub-optimizing.

Discussion

The six tests undertaken until now clearly show that *Byggelogistik* does not establish itself just because it has been decided to use it. It is a major turn around which should furthermore comprise all the participating companies in the building process in question. One company alone does not get anything near the same effect by doing it itself. The building process is a close co-operation between a large number of individual firms, and all of them must participate in any project aiming at a change in their way of co-operating. The introduction of *Byggelogistik* should be looked upon as a partnering project where a heavy involvement from the management is mandatory. All participants must feel that this is clearly to their advantage even though the savings and costs may not be evenly distributed from the start. The objective is to bake a bigger cake - not to share its increase fairly.

It is generally a requirement in any scientific experiment that it should be repeatable, and this requirement should be asked of any productivity experiment in the building industry too. But it is difficult to respect this requirement because so many external conditions play an important role in any building enterprise. No two building jobs are the same and most of the savings at a well planned job rise from unforeseen events not happening, the total cost of logistics are indeed not known at all. In experiments like this it is therefore

necessary to look for or count other indicators for improvements in productivity and let the exact measurements follow later. This lays claim to the qualifications of the members of the steering committee: they must know the practice in the building industry and the daily life on a construction site. They must be able to sense what works or does not work and they must have the seat of the pants' feeling that is so important in any construction management function. All this besides their essential capability of making a new and untraditional form of co-operation work. However, this does not make data requisition obsolete. On the contrary, one should collect data from all sources available - traditional as well as new - with the aim of understanding as much as possible about what is really going on at the building site. Frequent visits to the site are of great importance as well.

The *Byggelogistik* concept has up till now only been tried out in the social housing sector but the applicability of the concept in other sectors within the building industry has been investigated. It is the participants' opinion that the concept is applicable in any kind and size of building job. The savings will be found every time but the effort related to the planning will obviously grow by the complexity of the job in question. Churches and opera houses are indeed more complicated than residential housing and offices.

Byggelogistik is today a fully grown and operational scheme and the Danish Building Research Institute has issued a booklet introducing the concept to Danish building industry in general (Clausen et all 1996). This publication is one of the most quoted reports on productivity in the building process in the ongoing Danish debate.

Obviously minor improvements of the methods take place continuously, and the concept opens up for a more comprehensive planning of the building logistics *fi*, the management of equipment and site allocation. Also the 'information logistics' have been discussed. It is the opinion of the participants that the way architects and engineers provide their design information to the other participants in the building process is outdated. The format of drawings and specifications can be dated back to the days where drawing board, T-ruler and typewriter were their only tools. IT makes a much more suitable form of design information possible, tailor-made to the use in question: tendering, planning, ordering, construction and management. Time has come for a complete new thinking within this area.

This leads to a more general analysis of the use of IT in *Byggelogistik*. The design systems used by the architects and engineers in the tests can easily be used to specify and manage units. Contractors as well as suppliers use IT in their operations and planning, ordering and requests can therefore be made by EDI. However, isolated experiments have shown that even though this is the tool of the future, the Danish participants are not yet ready. Their systems are not tuned to this new form of co-operation and solving the technical problems costs more than the potential savings in the short run.

Conclusions

Efficient and systematic logistics following the ideas in the *Byggelogistik* concept may lead to substantial improvement of the productivity in the building process. More than ten percent is not an unreasonable expectation, to which should be added substantial savings in the materials costs. A total 5-10 percent cost reduction is therefore realistic. A similar reduction of the building price is harder to obtain because the benefits will be widely distributed among all the participants in the job in question. Only when the *Byggelogistik* principles are widely accepted within the industry and the concept implemented by all the participants in the process competition will lead to price reductions.

Even though *Byggelogistik* has proven itself a strong and very efficient tool in practise it has a number of pit falls which may lead to disappointment and lack of fulfilment of expectations. Careful management when implemented is mandatory.

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