

OBJECT ORIENTED INFORMATION MODELING FOR USE IN LEAN CONSTRUCTION.

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ABSTRACT

As part of the Danish Classification Project a report describing the information flow in a traditional building project has been published. By defining the final product as the building as well as the documentation, the value chain throughout the different phases of a Construction project is identified. Between the design and Construction phase the value-perception changes from adding value to the documentation to adding value to the physical Construction.

To reduce the amount of work converting the documentation to the exact information, the contractor needs to carry out each activity; a classification hierarchy based on the ISO 12006-2 standard is currently being defined. The hierarchy is being developed in preparation for introducing an object-oriented datastructure with "Work Result" as a common object for carrying information throughout the building lifecycle. "Work Result" is the outcome of the activities (*the transformation of resources*) in the Weekly Work Plan used in the Last Planner System.

At the same time the "Work Result" object is the link to integration between object oriented product models and process models, in this case the three levels of planning proposed in the Last Planner System.

KEYWORDS

Value chain, documentation, information flow, objects oriented, classification, and strategies of implementation.

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INFORMATION STRUCTURES IN THE DANISH BUILDING INDUSTRY

THE GENERAL BACKGROUND

Over the last 10 - 15 years it has become more and more obvious to the public in Denmark that the national Construction Industry is falling more and more behind the development in the countries with whom we normally compare ourselves. Our productivity in the industry is lower, the cost of buildings is higher, and the quality of the finished product is poorer.

The reasons for these very discouraging facts have been explained in many ways. "The excuses" vary from the lack of tradesmanship to the way we organize ourselves; the lack of structure in the project information, to the fact that the Construction Industry has had very little competition from companies based on our neighboring countries. Whether those explanations are true or not anybody can really tell. Under all circumstances there is not one single reason for the discouraging facts, and therefore no simple answers.

The Danish National Agency for Enterprise and Housing⁴ have focused on the use of IT and have over the past 12 years launched several development projects in an attempt to boost the industry. The effects of the over US\$ 150 million invested in those projects during the first 10 years were rather disappointing. However, over the last couple of years it seems as if the industry as a whole has recognized the need for change. There is a growing awareness of new possibilities, and a growing interest in test-projects showing potential benefits. The most encouraging interest is however, the recognition of the fact that we - to obtain results of any significance - have to work together and agree to a set of common rules primarily when you talk about information structures.

The Construction Industry in Denmark is by far the industry producing and making most use of information not only in volume but also certainly in variety and complexity. Even if the shipbuilding industry (in Denmark we have no aircraft producers) may be compared to the building industry looking at the volume of information, still the Construction Industry takes the lead. However the information structure used in Danish projects differs from project to project and common rules on how to present the information are not applied (though it could be argued that the lack of structure is the common rule in the sector).

In Lean Construction, information is considered to be one of the seven flows, but in reality information is much more than that. It is the basis for any planning at all. Therefore, any improvement in the basic information structure will be an improvement for planning at all levels.

LEAN CONSTRUCTION – DENMARK (LC – DK)

WHY LEAN CONSTRUCTION IN DENMARK

Danish Construction activities are at an advanced stage on a world-wide scale when it comes to innovation within the Construction Industry. Since the Construction Logistic

⁴ <http://www.ebst.dk>, only in Danish

experiments in the beginning of the 1990's, Danish innovation programs and the trade's work with a new Construction process have attracted international attention.

The Danish National Agency for Enterprise and Housing has announced that from July 1st, 2003 an application for publicly supported house building shall include a statement of the logistics of the project. That means a plan for controlling of flow of materials, information, equipment, personnel as well as activities. In fact, the principles of Lean Construction are close to becoming a legal requirement in parts of the Danish Construction Industry. Lean Construction – DK will participate in creating a common platform for development and distribution of knowledge – both nationally and internationally.

A firm joining LC – DK and co-operation with the LC - DK consultants will form a strategy for implementing Lean Construction. The consultants and the companies will co-operate on forming a “start-package” adjusted to the individual firms, which will help them to get started on the desired development. LCI represented by The Center for Innovation in Project and Production Management (CFI) and LC-DK represented by the Danish Technological Institute (DTI) agreed in April 2003 to collaborate in the development and deployment of knowledge regarding the management of Construction projects and other project-based productions systems. LCI will assist LC-DK to develop its own capabilities in this area.

A STRUCTURE FOR INFORMATION IN THE CONSTRUCTION PROCESS

BACKGROUND

The completion of a Construction project is foremost a question of communication, coordination and organization. In a normal building project thousands of elements are involved. They are all different in regards to type, dimension, quality, etc. Information on all these elements have to be communicated between an ever-growing number of companies and people who participate in the Construction project.

The poor managing of information is partly due to the large quantity of data that has to be communicated between the different parties and the project.

Information technology can help reducing repeated processes and errors but most important is that it can manage the trivial information jobs faster and easier. Project Web is an example of a tool where all information and documents are centrally placed and where all project participants have access. Hereby the project manager does not have to send information material to each party and can therefore focus on the critical planning and management of the project.

The use of information technology *demands* a shared information structure and agreements on principles and methods to achieve effective and integrated use of all project data.

Figure 1 shows an example on how you thorough preparation of the collected information can create relations between the documents.

Today we use the existing SfB- table⁵ as “Information Container”, all though the SfB-table has the latest revision in 1988, where a series of adjustments compared with the

⁵ SfB-table: a table where the elements of a building could be classified after.

starting point where done. The Danish SfB-table comes origin from an international collaboration in the 1950's.

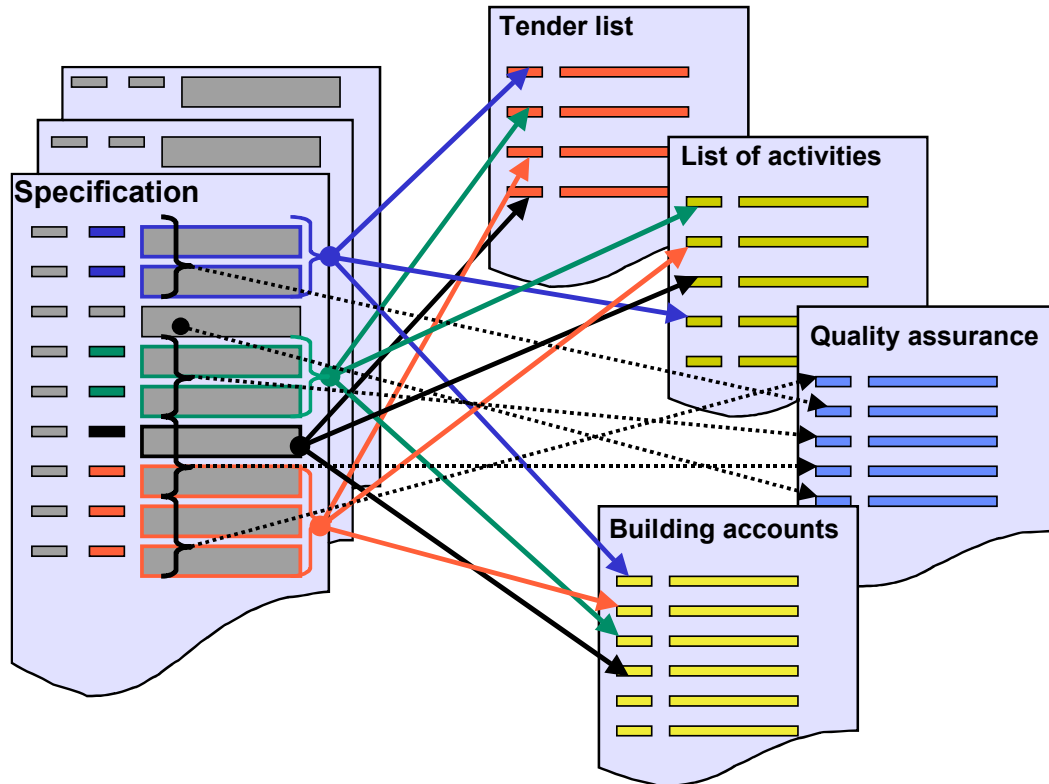


Figure 1: Specification data is used in automatic Production of several other project documents

In the year 2000 a rather big project (according to Danish standards) was started. The project aim was to create a new classification system for the Construction industry. The new system should be based on the element table of the SfB-system, which have been broadly used in Denmark since the 1960's.

The organization formed to carry out the project involved over 70 professionals from more than 30 companies, covering all aspects of the main issue. The work has recently been finished, and the final report has been published in May 2003⁶.

The classification that is used in a sector must reflect its practice and organization. The Construction Industry's traditional trade-barriers are currently under reconstruction for a more overall solution, using new methods for co-operation, e.g. partnering, Lean Construction, etc. That has created a new demand for knowledge sharing and uses of intelligent IT systems. Demands, which the existing classification system do not, satisfied. The lack of unambiguous information in the existing SfB-table has by several of the parties in the Construction Industries caused alienation to the use of the SfB-table. Instead the SfB-table has been replaced by self-developed adjustments by the individual user, or as a minimum by the individual company. Especially within the Construction

⁶ <http://www.byggeklassifikation.dk>.

engineers, there is limited tradition for using the SfB-table: That because the Construction Engineers do not find it possible to identified their work with the SfB-tables classification and concept. The result has been, that the parties in the Construction Industries have meet a different employment of building elements from project to project and from collaborator to collaborator – with missing opportunity to obtain a better efficiency saving.

This calls for a renewal and rethinking of the existing classification and establishes new relations etc. – towards generic classification and models. This means that others will have influence on information that you have had the ownership of. By taking part in a stunted developing of the connection between relevant classification systems in Denmark, and taking part in a further developing of the information Structure, which could contain the Last Planner System e.g. The Lean Construction – DK will be able to contribute in developing new, coordinating and useful tools for the parties in the Construction Industries. Equally the Lean Construction – Denmark to day in a less extent uses the information structure in its education to the Construction industry.

The attitude towards (and the use of) classification in the Danish Construction Industry has been pragmatic and perhaps this is why there is so much variation in Construction components. Figure 2 shows an example of a process model for a general contract.

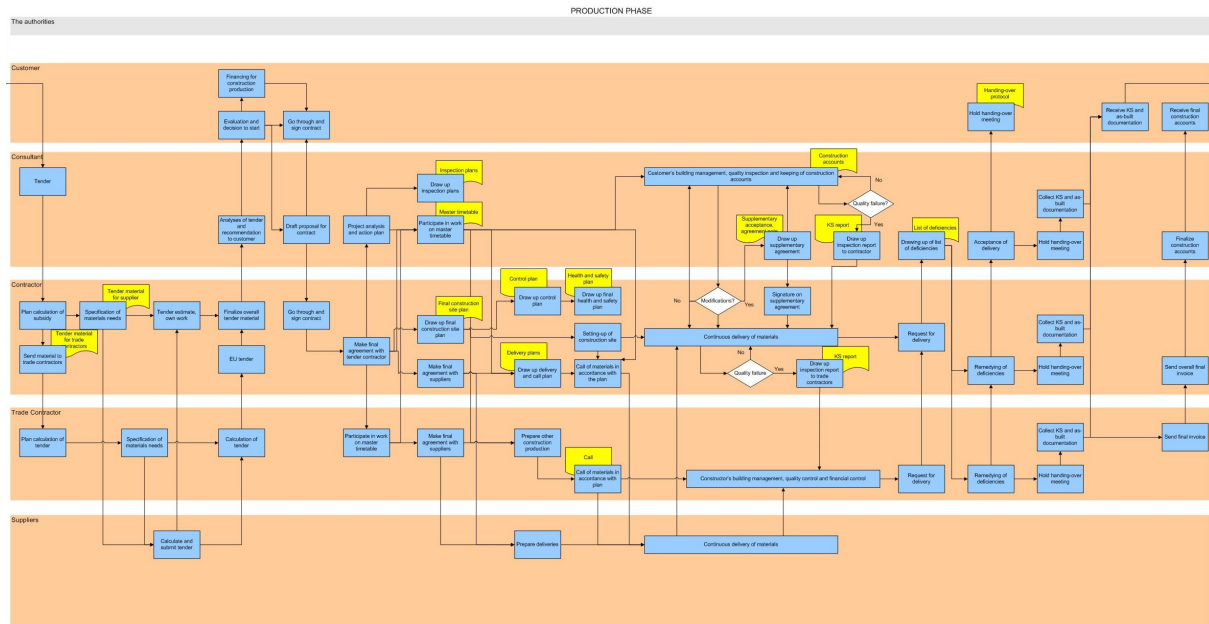


Figure 2: Part of the information structure, showing the phase of the Production

The model shows the flow of the needed information in the Production phase (without the use of The Last Planner System™) and the underlying information structure. The model can provide a visual orientation of the project progress from design to facilities management, including the information and documents that are needed in different phases. Are the model used in the projects start-up phase for explaining which

information needed to be flowing to which part and at which time, then the use of the model ensures better:

PLANNING AND CONTROL OF MATERIAL AND INFORMATION FLOW

Knowledge sharing and distribution

There have only been a few pilot projects in the Classification Projects, which have been starting in the developed structure for the flow of information in a Construction project. But everybody agrees about that a common Information Structure will secure the above-mentioned Benefit in a Construction project. Today we are still missing to carry through a complete Construction project, where the information structure are used and where the result are be measured.

The use of a common system for the structuring of information contains several perspectives in the form of saving of time and rationalizations through an efficient communication between the parties in the Construction Industries.

THE LATEST DEVELOPMENTS

The work in the classification group seems to have stirred a lot of other initiatives to action, so that we now find ourselves in a situation where coordination is a key issue.

The Danish National Agency for Enterprise and Housing has launched a new development project called "The Digital Construction Initiative " focusing on 6 main issues:

- Benchmarking and finding the best IT-practices
- Digital tender procedures and the use of bills of quantities
- Object oriented design and simulation techniques
- Project-webs
- Digital facilities management
- The digital information foundation / information structures

The sponsored development work will take place over the next three years.

Several authorities throughout the country have launched similar development projects in a smaller scale.

At the same time a group of consultants in collaboration with universities and others (see below) have focused on what they call "the use of intelligent modeling in the Construction Industry" implementing building-, process- and product-models. In this, group there is also an intention to reuse information and automatic or semi-automatic Production of new documents based on the basic information found in the specifications, whether you find this information in the traditional documents or as part of object information in the intelligent building models.

These new techniques seem to have a great potential. Objects containing all information about the building elements such as geometry, materials, quantities,

maintenance, work descriptions, and schedules can be used in all parts of the buildings lifecycle and reduce redundant data, re-typing etc.

OBJECT ORIENTED INFORMATION MODELING

Although some experts argue there is little room for computers in a Lean environment, others recognize that information systems can play a key role — as long as Lean principles are upheld. Information systems must not be used to merely automate a poorly designed process. Instead, Lean systems can be used to support and illustrate the Last Planner's work as well as an aid to identifying and eliminating constraints.

With this in mind the outcome of the Classification Project has been used as basis for developing IT-tools for the use of the Last Planner System in integrated design, and for maintenance-information throughout the buildings lifecycle.

DATASTRUCTURE FOR USE IN LC/LPS

In the Classification Project the decision was made to work with a datastructure corresponding to ISO 12006-2. The lowest level of granularity was set to "Work Result", analogous to the outcome of an activity. In the Last Planner System this is the exact level, which is used in the Weekly Workplan and can be aggregated into Building Elements in the Lookahead Plan, as illustrated in Figure 3.

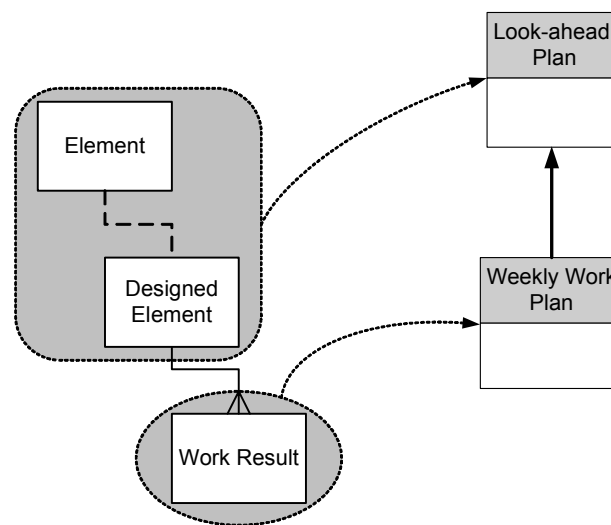


Figure 3: From building element through "work result" to the Last Planner™ System

Today's lack of object oriented datastructure means that the Last Planner™ System Tools do not make full use of its potential. The objects ("Work Results") does not contain any of the information added by the designers, information about the exact products, resources, geometry, etc., even though all this information is available and stored in other documents. The Last Planner System offers a methodology for keeping track of the constraints but the necessary information still has to be recovered manually.

Having a full object oriented 3D model of the building would be the ideal situation. It has all the advantages for visualization and simulation, and each object contains information about relevant attributes.

The objects can then be directly used in the LPS' Lookahead Plan and Weekly Work Plan at different levels of aggregation (illustrated in Figure 3).

DEMONSTRATOR

In a Master Thesis two students from Aalborg University in 2001-2 has been working with the developing of a prototype demonstrator.

A demonstrator of the principles illustrated in Figure 3 is currently being developed through use-case programming, based on the datastructure from the Classification Project and user demands.

The user interface of the demonstrators Weekly Workplan is shown on Figure 4. Details about materials, which Building Element the task is part of, a description etc. is attached is attached to each task. If changes are made in the original drawings/models, the tasks are automatically updated.


Weekly Workplan			Kontakt:		<div>Lean Construction - DK</div>						Opfølgning
Tasks			email:		Week <u>12</u>						
			Tlf.								
			Fax.								
Sort	Genganger	Aktivitet	Ansvarlig virksomhed	Forudgående arbejder	man	tirs	ons	tors	fre	Bemærkninger	Completed (Y/N)
1		Opsætning af stillads inkl. plastafdækning	<div>Materials Description Part of...</div>		X	X	X	X	X		
2		Installationer			X	X	X	X	X		
3		Vægge i lejligheder inkl. dørhuller			X	X	X	X	X		
4		Gulve inkl. indskud vægskaderum samt afdækning		Ne	X	X	X	X	X		
5		Nedrivning i kælder		Ne	X						
6		Nedrivning på loft	Ne		X						
7		Udførelse af svampe/rådeskader	Tø+Mu		X	X	X	X	X		
8		Murerarbejder i kælder inkl. fundamenter	Mu	Nedrivning kælder		X	X	X	X		
9		Nedrivning af trappeløb til kælder	Ne		X	X	X	X	X		
10		Støbning af nye trappeløb	Be		X	X	X	X	X		

Figure 4: Weekly Workplan in the Demonstrator

The Lookahead Plan is shown on Figure 5. The tasks ("Work results") from the Weekly Workplan are aggregated into "Building Elements" and the relation between them is kept. This means that if a Task in the Weekly Workplan is delayed it is automatically updated in the Lookahead Plan, which also keeps track of milestones.

The connection between the two plans means that changes made in one immediately shows in the other and the consequences of delaying or moving tasks are shown. Redundant data and re-typing is also avoided.

DATA STRUCTURE

Experience has shown that it is necessary to distinguish between physical elements and Task in the datastructure.

The physical elements are the elements, which stay in the building after the Construction phase and the machines and temporary constructions used in the process (e.g. shuttering, scaffolding). The primary distinction between the two types is how these

are used. The elements stay in the building once it is used, whereas machines are used for a period of time and then made vacant again.

The physical elements are gradually specified through the process until a specific product or machine can be appointed to the Task.

Tasks are the operations that combine, uses or produces physical elements.

LOOKAHEAD PLAN			Kontakt:		Lean Construction - DK																
			email:																		
			Tlf.																		
Tasks			Fax.		Constraints																
Sort	Gænganger	Aktivitet																			
		</																			

Figure 5: The Lookahead Plan in the Demonstrator

THE DIGITAL FOUNDATION

The Danish National Agency for Enterprise and Housing has initiated "The Digital Construction Initiative". A part of this initiative is "The Digital Foundation" which has the purpose of creating an object-oriented datastructure in preparation for data integration between all the parties concerned in the Construction process throughout the lifecycle of the building.

"The Digital Foundation" can be seen as a successor of the Classification Project, and has, along with two other initiatives ("Best in Construction: Benchmarking for IT-tools in the Construction industry" and "Building owners demands: Digital demands"), been granted a total of € 2.7 million from the Danish government.

USER REQUIREMENTS

The IT tools has been developed using use-case programming. Through interviews, the requirements have been mapped out to the following:

REQUIREMENT TO PHASE SCHEDULING TOOL

- Superior order of tasks.

- Critical path.
- Identification of critical deliveries.
- Milestones.

REQUIREMENT TO LOOKAHEAD PLAN

- Detailed description of tasks with prompt for constraints.
- Constraint analysis.
- Constraint survey based on constraint analysis.

REQUIREMENT TO WEEKLY WORKPLAN

- Registration of actual time used on each Task
- Automatic update of Phase Schedule and Lookahead Plan.
- Specification of consequences when moving or delaying tasks.

THE FUTURE

Many in the Danish Construction Industry have, during the last couple of years, looked at the developments taking place in Finland with envy. The Finish authorities have invested hundreds of millions of US\$ in boosting their Construction Industry and the big organizations in Finland have joined in. The results of the joined efforts have brought the Finish Construction Industry up among the leading countries in the world, and a new national multi-million (€ 400 million) development project has just been launched.

In Denmark, there is no tradition for the same kind of approach as in Finland. The Danish authorities are more restrictive, expecting the organizations and companies themselves to take the risks and investing the necessary money. If the authorities see this approach they will support with up to 50% of the necessary capital.

Lately the earlier mentioned group of consultants have gathered around the idea of forming a network of technical service institutes, universities, consultants, contractors, software companies and building material producers with the common goal of supporting the implementation of intelligent modeling techniques in the Danish Construction Industry.

If this network succeeds we will expect the following developments to take place in 4 to 6 years:

- the 2D and 3D Cad-technique have been replaced by true object-oriented design technique and used in building models
- the possible visualization and simulation techniques introduced by the models mentioned above will be widely used
- the present lack of a common information structure have been replaced by a structure known by everybody and used by the majority

- process models telling who is doing what when, showing the sequence of events, and the same time used as the main tool in quality assurance and control will be broadly used in the projects
- the producers will have developed quite a number of Production models, placed on the internet for the architects and engineers to use them in their design work
- Almost all projects will use the project-webs, and the main part of all tenders will take place using the Internet.
- The new way of doing things will prove to be more efficient, improve earnings, lower the cost of building and increase the export of building products and know-how - and last but not least will improve the quality of the finished product.

It is expected that the Danish Construction Industry in that way will be able to jump from the vicious to the good circle of events.

REFERENCES

- Alarcon, L. (1997) *Lean Construction*, A.A. Balkema Publishers, Rotterdam, the Netherlands.
- Ballard, G. (2000). *The Last PlannerTM System of Production Control*, PhD Dissertation, School of Civil Engineering, The University of Birmingham, U.K., May.
- Ballard, G. (1994) *The Last PlannerTM*, Northern California Construction Institute, Monterey, California, April.
- Ballard, G. (2000) "Managing Work Flow on Design Projects", *Proceedings CIB W96*, Atlanta, GA, May 19-20.
- Ballard, G. (1999) "Improving Workflow Reliability", *Proceedings Seventh Annual Conference of the International Group for Lean Construction*, IGLC-7, Berkeley, CA, July.
- Ballard, G. (1997) "Lookahead Planning; The Missing Link in Production". *Proceedings of the 5th Annual Conference of the International Group for Lean Construction*, Griffith University, Gold Coast, Australia, July.
- Berger, D. (2002) *Apply Lean to IT-systems*, 2002, September
- Brondsted, J., and Larsen, K. (2002) *Use of metadata in the building process*, Master thesis Construction Management, Aalborg University, June
- Choo, H.J., Tommelein, I.D., Ballard, G., and Zabelle, T.D. (1998) "Workplan: Database for Work Paccakage Production Scheduling". *Proceedings Sixth Annual Conference of the International Group for Lean Construction*, IGLC-6, August Guaruja, Brazil,
- Goldratt, E. (1992). *The Goal*, North River Press, 1992.
- Howell, G. (1999) "What is Lean Construction". *Proceedings Seventh Annual Conference of the International Group for Lean Construction*, IGLC-7, Berkeley, CA, July

From the Danish Centre Contract on Classification in Buildings

Howard, R. (2002). *Research on international experience and future developement in IT*, The Danish Technical University

- Howard, R. (2001). *IT Barometer Survey, The Use of Information Technology in Building*, The Danish Technical University
- Howard, R. (2001). *International Practice and Experience*, The Danish Technical University
- Kobbero, I., and Skovsende, S. (2002). *New Building elements*, Article only in Danish
- Skovsende, S. (2000). *Nordic Building Element Tables*, Article only in Danish
- Skovsende, S. (2000). *Revision of the Sfb-system*, Article only in Danish