The Scandinavian construction industry is witnessing exciting change. Professors Thomas Olofsson and Lars Stehn of Luleå University of Technology, Sweden address the different elements and thought processes considered in their research on industrialised construction.

Could you discuss some of the theories that you have developed to aid industrialised builders in their development of building concepts?

Our research helps the industrial builder to develop building concepts as modularised product platforms for the targeted market niche. We therefore employ modularisation techniques found in manufacturing research, issues from quality engineering connected to lean manufacturing and construction and engineering design. However, the product platform needs to be adapted to the production system and implemented business model to reduce the financial risk for the industrial builder.

Our target here is an ICT tool-based approach utilising Building Information Modeling (BIM) models and simulation methods to investigate variation in demand and output. To build up a business offering we employ industrial marketing and sometimes industrial organisation theories. The understanding of how different types of industrialised building concepts affect the industrial builder’s position in the supply chain and the way construction projects can be performed is crucial on a strategic managerial level. Our theoretical models include adaptation of strategic management, supply chain management and decision making models. This will impact on sales strategy and long-term relationships with up stream and down stream partners in the supply chain.

How have these theories developed into practical methods, strategies and tools for product development and project customisation of industrialised building concepts?

In the product development phase we have adapted modularisation theories used in manufacturing and in the development of modularised building concepts. More specifically we propose that the development of a so-called ‘technical platform’ is based on functional requirements while the configuration of specific building products or volumes is based on geometric grids. Constraints from preproduction, transport and assembly must be taken into consideration in the development phase. In the project customisation phase different strategies and tools are proposed depending on where in the product specification process the customer design entry decoupling point occurs. Sales, engineering or architectural configurators can be developed to customise product families or configurable building concepts. When the solution space becomes larger, traditional architectural or engineering methods are suitable. Based on lean thinking and value flow with engineering design we have developed a coordination process tool for industrialised housing design. The coordination tool gives the company the possibility to perform multiple projects and, via gateways, control the input and output of different design steps.

To what extent does customer product specification impact on, and limit, construction techniques? Have you factored changing customer specification into your strategies for industrialised building concepts?

Customer requirements of the use of specific technical solutions in the design can limit the possibility to use industrialised building concepts. Normally, building concepts are developed to fulfil a number of functional requirements such as fire, insulation, deflection, strength and constraints from the production system. Requirements of specific use of technical solutions can affect the functional specification and production constraints of the developed building concept, often with considerably higher production costs as a result. Of course, a well designed building concept should offer customisation possibilities for parts or solutions that are of value to the customer. Customers may change their requirements during the course of time in a traditional construction project. This might not be possible in an industrialised construction project since the time between order and delivery is in general much shorter compared to traditional construction projects.

What are the financial implications of this construction technique? How can your research help to reduce costs?

Traditionally, construction projects produce ‘one of a kind’ products using temporary organisation and site production. Often the principal construction company that manages a construction project executes only a small part of the ‘product’ using its own personnel and its own production facilities. The great part of the product’s value is built with help from suppliers and subcontractors. This strategy minimises the economic risk for the principal construction company but also prevents the attainment of flows as efficient as in the manufacturing industry. Investing in the development of a building concept will most certainly reduce the cost of production in a specific project. However, the profit made in individual projects where the building concept is customised must cover the cost of product development and the fixed costs of production facilities in which the industrial builder has invested. Therefore, a large part of our research is devoted to developing efficient production systems through means such as lean production tools.
Assembly over manufacture: the fabric of construction

Construction companies have long followed the accepted method of ‘engineer to order’ as a basis for designing and completing building work. As the potential of technology changes with the times, so too do the accepted processes of construction, with off-site assembly coming increasingly to the fore.

OVER THE LAST decade, construction companies all over Sweden have begun to steadily embrace the idea of industrialised building, especially in the timber housing industry. The concept of industrialised building involves companies moving a significant amount of their construction away from sites and into factories. Factories then make the products and platforms that are needed to assemble a company’s building design on site. Businesses are able to specialise in this way by exploiting the prefabrication methods made available by industrial business practices. An increasing number of SMEs in Sweden, for instance, now specialise in multi-storey housing construction.

Traditional methods of construction have been favoured over the years. This has been in part due to their ability to complement a more ad hoc style of working. Whenever a building is designed, room is left between the planning and execution stages for any design alterations instigated either by the architect or client. While accommodating to the business in one way, this method can lead to a construction company running its manufacturing and assembly on site, resulting in much higher costs than originally forecast.

Wishing for ways to combat the over-expenditure brought on by traditional practices, many businesses have decided to place more importance on new, less costly methods of construction, such as industrialised processes. The industrial builder will forgo many unforeseen costs by designing and manufacturing the majority of products before any building is actually carried out. Building in this way allows a company to remove much of its manufacturing away from contractors and into its own factories, holding on to more profit as a result. Conversely, while significantly reducing ad hoc costs, more industrial methods mean that the company is less flexible when it comes to customer demand. For this, the builder has to offer customers a prospective building design much earlier in the value chain.

GETTING INVOLVED

Building concepts can now be categorised depending on when a client becomes involved in the product specification process. The traditional ‘engineer to order’ process, for instance, begins from scratch and is based on user requirements,
In order to address these different building techniques and the potential they offer, Professors Thomas Olofsson and Lars Stehn, and their research team at the Luleå University of Technology, Sweden are focusing their research on industrialised construction. Their research community aspires to be a leading European innovation centre for research into efficient production systems, product platforms and business models in the construction industry.

The group believes it is possible to introduce industrial thinking and methods to the traditional construction trade through supply-driven innovation. "The idea is that suppliers with production facilities coordinate and work in long-term cooperation with other suppliers and consultants in the housing value chain to build platforms for the integrated development of products, processes and business," Stehn explains. The objective of the team's research is to develop new theories and methods for industrialised builders to select the strategies and tools they need for efficient development and customisation of industrialised building concepts.

In order to carry out their research efficiently, the group maintains three simultaneous foci: business, academy and society working together. This triple helix context has been especially exhibited through the Lean Wood Engineering (LWE) centre, where a great deal of the team’s industrialised construction research takes place. LWE is a competence centre for research and development within industrialised timber construction, wood manufacturing and interior solutions. Led by Professor Lars Stehn, the LWE centre involves around 30 senior researchers and PhD students. The centre works as a joint venture between the Luleå University of Technology, the Institute of Technology at Linköping University and the Faculty of Engineering at Lund University. The centre also works in collaboration with wood and wood-manufacturing industries and stakeholders within the building sector.

**SWITCHING ROLES**

Olofsson runs the research project ‘Managing user requirements in industrialised building concepts’ in partnership with the Faculty of Engineering at Lund University. In this project, his team is investigating the changing role of clients, contractors, architects and engineers in a more industrialised building process. The team has found that in highly industrialised building concepts (where up to 90 per cent of the product is prefabricated before reaching the site) the construction process is shortened to such an extent that the design process becomes the bottleneck. This owes to the fact that although construction is much faster, the prospective customer still needs to be able to approve the design and any proposed alterations before manufacture can begin. The idea behind industrialised construction, therefore, is to also reduce the time taken up by the design process by making the customisation as efficient as possible within each design.

The research group has already seen great success, particularly from the market success of timber volume element companies. At the beginning of their joint research and development work, the market share was less than one per cent. “After 15 years of tight collaboration, this has increased to 15 per cent, which is the total market for multi-storey dwellings in Sweden,” Stehn explains. Of these multi-storey buildings, 15 per cent are constructed using industrialised timber systems.

Olofsson’s and Stehn research is performed in close collaboration with industrial partners, including Lindbäcks Bygg, Moelven Byggmodul, NCC, Tyréns and SKANSKA. The team also works alongside material traders such as CEMENTA and Betongindustri, who have contributed research on industrialisation in civil engineering construction.

Working alongside the people most affected by their research, the research group gains a lot of knowledge from their industry partners. Tyréns, a Swedish engineering company, is currently developing an open configurable building concept with LWE, while SKANSKA is devising a select variant building system that is able to offer more configuration to the client.

Researching new theories and strategies of construction has led Olofsson and Stehn’s research team to predict how different roles may change in the future. As more companies and markets embrace industrialised building concepts, there will be a greater need for qualified engineering work. The role of the architect will also change, becoming more of an industrial designer and requiring more collaboration with each member of the value chain. Architects and engineers will have new tasks of design automation and development of configuration tools. Anticipating this change in industry standard, Luleå University of Technology has already begun educating civil engineers in industrialised construction. “Since more construction work will be standardised and probably moved to factories and construction sites will be changed into assembly sites, the demand for skilled construction workers will be less,” Olofsson states.

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**INTELLIGENCE**

**INDUSTRIALISED BUILDING CONCEPTS**

**OBJECTIVES**

The aim of our research is to develop theories and methods applicable for the integrated development of products, processes and business for industrialised builders, regardless of what is built and by whom.

**INDUSTRIAL PARTNERS**

Lindbäcks Bygg
Moelven Byggmodul
NCC
Tyréns
SKANSKA
CEMENTA
Betongindustri

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