MANAGING CONSTRUCTION PRODUCT INNOVATIONS

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Abstract

The objective of this paper is to contribute to exploring innovativeness of the construction sector through characterization of the construction product innovations from the viewpoint of a product manufacturer. The primary research problem concerns an innovation process of a company: What kinds of activities does a manufacturer have in its pursuit for novel products, and how they are organised and managed? This kind of firm- and micro-level research approach is in line with the recent innovation research streams. The aim is also to give more insights to phenomena that favour or hinder product innovations.

The case study approach is chosen due to the rather small number of publications that deal with the construction product industry on its own terms. An innovation process is studied through a longitudinal single product case that was selected based on the companies' innovative product portfolio. A product innovation is defined as a solution that is either patented or/and brought to the market via a national or a European product approval route. The product case represents an advanced composite construction technology whose penetration to the market required research-intensive phases and knowledge-intensive services. Description of its innovation process from idea generation to the markets and succeeding incremental developments until recent years was based on interviews, documents and collaborative analysis of findings. The innovation theory of Nonaka and his colleagues was applied to analyse the results. The main conclusion is that managing of knowledge enablers is vital to innovation processes of a growth-oriented construction product manufacturer.

Key words: Construction, co-operation, knowledge, product innovation, R&D

INTRODUCTION

Evolution in building and construction technologies has characteristically taken place through uptake of achievements of several sectors such as materials, machinery, energy, and manufacture. Construction product industry plays an important role in complex implementation processes as a supplier of materials, products and systems to the actual building projects. A construction product is defined as a product that is sold as entity to be used in a permanent manner in the "works" that are end-products of construction activities, such as buildings.

Importance of product innovations to material costs, productivity, performance of a building project and performance of a completed building has been recognized in research. Further, many researchers have concluded that most construction innovations originate from material and component producers whose investments to R&D are also the largest share in the construction sector (Gann 1997, Manley 2008). According to Schartinger (2009), radical innovations are more likely in this segment of the sector than in other ones.

However, approaches of innovation science have rarely been applied to construction product industry. A background for this neglect is most likely the economics-oriented tradition of innovation research. Squiqqiarini and Asikainen (2011) referred to the influence of economic classification on the measured innovativeness of the construction sector, and proposed a broader definition that would embrace both upward and downward processes in addition to the NACE Group 45 that in common refers to the construction sector (Figure 1).

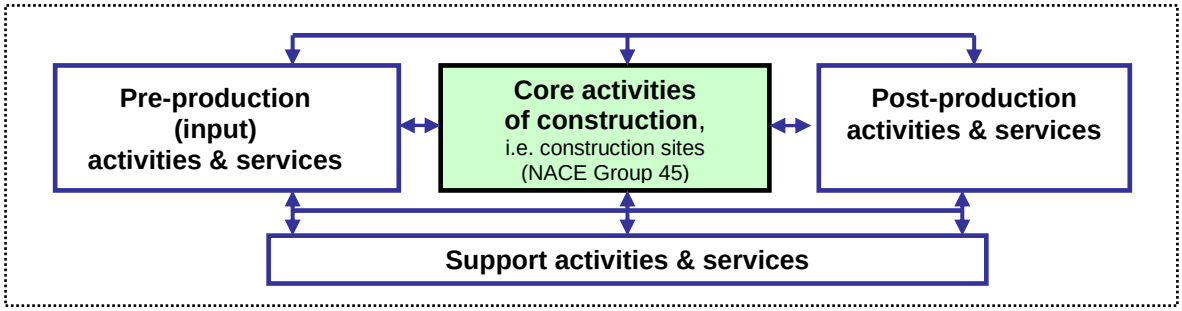


Figure 1. Manufacturing of the construction products belongs to the "pre-production" in extended sector classification (Squicciarini & Asikainen 2011).

In this study, the construction product industry is defined as a compilation of various subsectors of manufacturing and chemical industries that are suppliers of the construction sector in an identifiable manner, in accordance with a recent European analysis on competitiveness of the construction sector (Ecorys 2011).

Research problems

The primary research problem concerns an innovation process of a company that manufactures construction products: What kinds of activities and capabilities does a manufacturer have in its pursuit for novel products? Several complementary questions can be introduced: How are these activities organised and managed? How does the company reflect and react to the market changes? What kinds of strategic alliances does the company have and why? How are individuals encouraged to share their knowledge? These kinds of firm- and micro-level approaches are in line with recent streams of innovation research.

The findings are compared with models and concepts of the theory of Nonaka and his colleagues (Nonaka 1994, von Krogh et al 2000) in order to study the applicability of the theory in the context of small- and medium-size company that manufactures construction products. The issues concern company's managing methods to create, process and accumulate its knowledge assets. This framework was chosen by the research organisation based on the literature survey for the following reasons:

- The theory is generic considering knowledge as the key concept;
- The theory deals with an entire innovation process from the fuzzy front end to a launch of a novel solution and service, and further a continuous spiral;
- The theory comprise aspects of several research streams such as innovation capabilities, organisational learning, organisational cognition, multifunctional teams, micro-foundations, knowledge management, alliances and networking;
- The theory concerns both intra-firm and inter-firm interaction; it has also been applied to research-industry-interaction and construction sector;
- The theory emphasizes trust, care and personal interaction that are regarded as important for managing expert services as well.

An embedded research problem concerns the definition of an innovative construction product, in other words: How novel construction products are actually launched in the markets and implemented in building projects? Reasoning of this problem is the OECD's definition of a product innovation (2005) as "the implementation of a new or significantly improved product (good or service)": trading of new or modified construction products is tightly regulated in the national and European markets based upon the Construction Products Regulation (CPR 2011) and preceding Directive.

RESEARH METHODS

Case study approach

The case study approach was selected due to the exploratory and descriptive nature of work. The aim is to understand phenomena within their own context-specific settings (Gray 2009). The unit of analysis is an innovation process of a construction product manufacturer. The company Peikko Group Oy was selected purposefully by the research organisation thanks to its continuous innovation activities and open publication policy. The embedded case is the innovation process of the product Deltabeam. In addition, the case study is also longitudinal based on glances at the evolution of the company and the product.

The primary source of information was interviews of the personnel of the company. Secondary sources were the company's customer magazines Peikonlehti/ Peikko News and Concrete Connections as well as company's website, patent documents, professional journals, bibliography of the company's founder (Seppälä 2009), annual reports of the company, and the histories of the Finnish building technologies.

Interviews and collaborative analysis

The interviews were conducted in two phases: two individual and semi-structured interviews aimed at identification of factors of successful product introductions, and the succeeding non-directive interviews aimed at validation of preliminary findings. The individual interviews were planned, conducted, recorded and reported by the research organisation. The questions aimed to unveil the knowledge creation practices, and management of knowledge enablers that are described as "instilling vision, managing conversations, mobilizing activists, creating right conditions, and globalizing local knowledge" (von Krogh et al 2000).

Interviewee A, Senior Adviser Jorma Kyckling joined Teräspeikko in 1985 as Managing Director, and changed to manage Deltatek when the production of Deltabeam began. Interviewee B, R&D Manager Simo Peltonen joined Deltatek in 1997. They assessed the preliminary findings, and are also authors of this paper. Further, the results and conclusions were discussed and developed in a meeting with Director of R&D Taru Leinonen (joined Peikko in 2000) and Director of Product Management Raimo Lehtinen (joined Peikko in 1989, Managing Director 1992-2010).

THE CASE COMPANY AND ITS INNOVATION CASE

Company and its innovation organisation

The Teräspeikko company was founded in Lahti, Finland in 1965. The founder of the company Jalo Paananen was a salesman who visited building sites frequently. He was once asked whether there could be any means to produce tie trusses of façade panels off-site because manual labour on-site was tedious and expensive (Seppälä 2009). After a short while of brainstorming conversations together with experts on steel materials and manufacture, a new company was established by the involved team. The product was the first prefabricated solution on the niche market that has been growing ever since (Customer Magazines, 2/2009). In Finland, prefabrication of concrete components took place from about 1955 to 1970, and industrialisation continued in the 1970s. Supplier companies have had an essential role in industrialization and implementation of the national open building system (SBK 2009).

The name of the company was shortened to Peikko in 2005. The Peikko Groups' wide-range product portfolio still focuses to the connecting technologies of prefabricated concrete structures. Its other competence area is composite construction. The industrial sub-class is "Manufacture of structural metal products" (DJ28.2 in the NACE classification of the EU), which means the upward activities of the "construction sector" (NACE 45). On the other hand, the connecting and reinforcement products are manufactured from steel plates and re-bars, and the company is also an important downgrade operator (Customer Magazines, 1/2008).

The next generation of the owner family has managed the company effectively since 2007; Mr. Topi Paananen, started as company CEO in April 2010. The first steps of internationalization were taken already in 1990's with establishing sales offices in Europe. Today, the company operates in 30 countries in Europe, North America, Middle East and Asia, and employees around 800 persons; the number of Finnish employees is about one fourth. The growth has been organic with no major acquisitions.

Peikko Group has a clear focus to regularly introduce innovative solutions and services. The investments in R&D were 1.6 Million Euros in 2009 which is among the highest in the field. The R&D function is managed at the headquarters in Finland, but the operations are done locally. The multicultural team is responsible for the acquisition of state-of-the-art knowledge, a new product development and product approvals as well as IPR issues. It contributes to the customer service, and a job circulation policy between various functions is traditional. Most employees have an academic education in civil engineering and four holds a doctoral degree.

The R&D unit has a central role in the company's "invention policy" that aims to encourage all employees to come up with new ideas. The company is a member of The Concrete Association of Finland BY and The Finnish Constructional Steelwork Association FCSA through which information about European standardization is available. The company also participates to standardization. The affiliated companies tend to participate in national network in their countries.

Innovation Case: a composite beam from the idea to the building projects

There was a hunt for new product ideas in Teräspeikko in 1988 (Seppälä 2009). The Interviewee A proposed a "composite beam" to the founder and CEO of the company in the spring. He had become familiar with recent advancements in the steel-concrete composite structures, and a Swedish composite beam solution. Further, the company had some experience in manufacture of steel beams. An expert team was established in the autumn, and soon the concept of a shallow beam emerged. Although all the members had an education in structural engineering, their professional expertise was complementary covering commercializing, research methods and building regulation. The success story of the innovation process is presented in Figure 2.

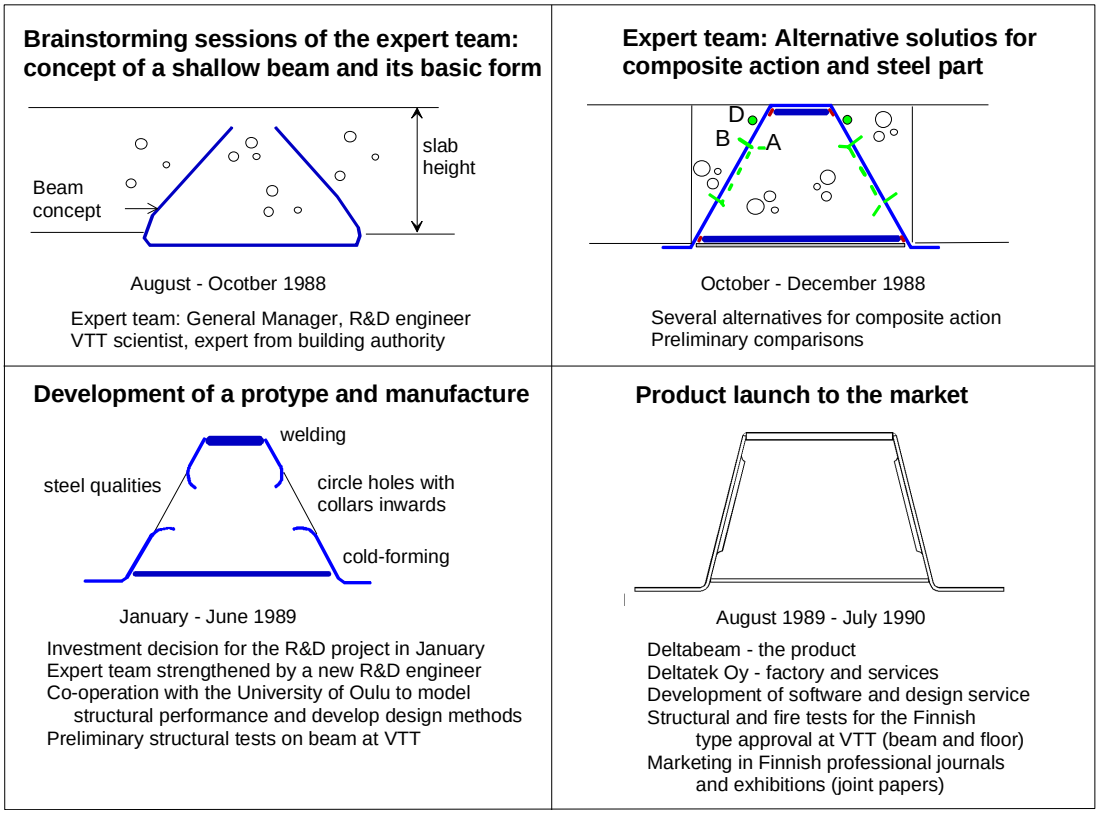


Figure 2. Innovation process of the Deltabeam from an idea to the market.

The major marketing arguments of the slab height composite beam were its hidden position and fire resistance. Composite action also allows for about 30 % saving in the steel material use compared to a plain steel beam of the same height. Further, the solution allows for a flexible lay-out (Kyckling et al 1990, Nykyri et al 1990). The innovation was launched in the national construction exhibition in the spring 1990. The national patent was published in 1990, the European one in 1994.

The Deltabeam was on the market in two years after the vague first idea. Despite of the relatively fast process, the product was late on the market in the sense that the economic recession started to slow down construction activities. The commitment and skills of Managing Director Jorma Kyckling were vital for saving Deltatek during the first negative years and later in fast growth of production and markets (Seppälä 2009).

Continuous R&D of the product and related services

Analysis and design methods of the Deltabeam have been developed and experimentally validated in several research projects since the launch in the Finnish market (Table 1).

Table 1. R&D of the Deltabeam solution after the first launch.

Subject	Publication in theses or conference, scientific or professional papers, by	Schedule	Contributions	
			Own	Research Centre or University
Design methods, phase 1	Researcher, 1991-1992	1990-92	x	OY
Floor with hollow-core slabs, tests (joint effort)	Researchers, 1998	1990-1994		VTT
Composite action*	Doctoral thesis 1995	1992-1995		HUT
Floor with big beams **	Reseachers	1995-1999		VTT, OY
Design methods, phase 2**	Researcher, 1997-2002	1995-1999	x	OY
Fire tests**		1995		UB/ GER
Push-out tests	Joint paper 2006	2002-2003	x	OY
Design methods, phase 3	Joint paper, 2010		x	OY
Fire tests	Joint paper 2009	2008	x	SP/SWE
Manufacturing	Theses 2009, 2010	2008-2010		Applied Sc.
Carbon footprint (outsourced)	Joint conf. paper	2010	x	

"Researcher" as publisher means that the outsourced organisation has had a permission to publish. "Joint paper" has involved also R&D Manager Simo Peltonen. OY means University of Oulu, HUT Helsinki University of Technology, UB University of Braunschweig, Germany, SP Swedish Fire Laboratory in Borås. * refers to Academy of Finland, ** refers to the national FinnSteel Programme of the National Technology Agency.

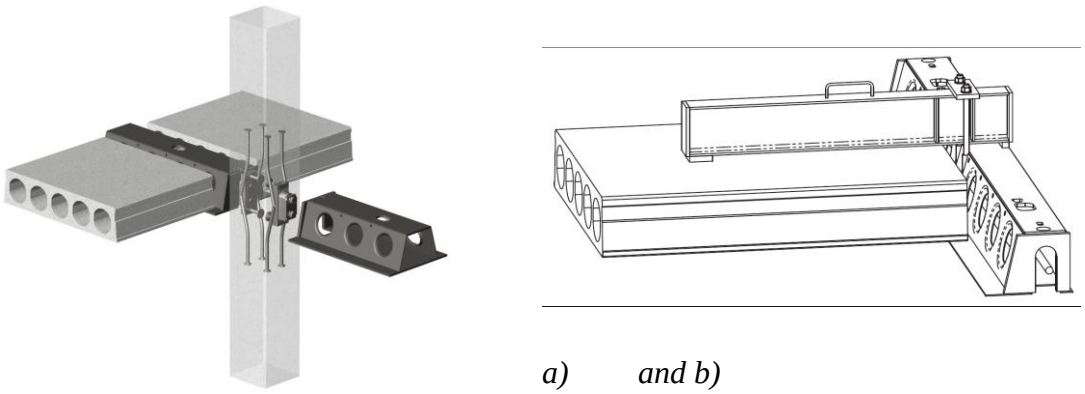
The main cause for continuous efforts has been the tradition of national type approvals because they have relied on the product-related design methodology and experimental verification. Co-operation with University of Oulu, and especially with Dr. Matti Leskelä, has been of great importance, and it is also buffered by a long-term contract. This co-operation has enabled contribution to the European standardization and a fruitful networking. Major part of market establishments and development of know-how has been realized through own R&D investments. The next step will probably be applying for the ETA (European Technical Assessment).

The sales of the Deltabeam has increased remarkably year after year. The number of reference building projects is about 6000 now, mainly in the Nordic countries. A

major enlargement of production took place in Finland in 2005. Production in Slovakia began in 2008. At present each beam is modelled individually and the production is totally automatized.

Growth of the composite building system

The product portfolio of Peikko Group makes an entire composite building system nowadays. The steel tube product is used as a part of a concrete filled composite column. Beam-column-connections are industrial products that are easy to handle during casting, hidden in transportation and again easy and safe to handle on site. They can be used together with concrete or composite structures (Figure 3a). Improving of the occupational health on the building sites has been one line of innovation activities. Peikko's products have always had a set of guidelines for designers and builders, but a system for safe installations and products for improved measures are also available such as railings and temporary supports (Figure 3b).



a) and b)

Figure 3. a) Deltabeam and connection to a concrete column, b) assembly support.

The company emphasizes co-operation with its clients as a source of new product concepts and as a key for success in the market. As an example, the Deltamix concept developed to the Spanish market together with Hormipresa combines expertises of both companies (Customer Magazines, 2/2011). Peikko's supply to a building project is often planned collaboratively with designers. This mindset has led to a great number of different references in different countries where the local materials and solutions are used together with Deltabeam.

Joint research projects are regarded as important to improve the state-of-the-art of special types of products and to strengthen basis of design methods in Eurocodes, and further to ease the product approval procedures. A research partner is usually appointed from the country in which a project for a European Technical Assessment/Approval is established. External R&D services have been utilized in issues for which there are no standardized methods or when experimental verification is needed, e.g. seismic, fire, vibration, and concrete anchoring strength. Future research co-operation models are under development process, and expansion outside Finland seems obvious.

One example of the joint marketing is the contract with the Finnish Tekla whose 3D-design software is used in building projects world-wide (Customer Magazines, 1/2007). The continuous development of design software has been a key to successful implementation to building projects in new markets, too.

ANALYSIS: CLIENT-DRIVEN PRODUCT INNOVATIONS

Analysis of the innovation case

The construction product innovations of the case company Teräspeikko/ Peikko Group facilitate the successful growth and internationalization. They are typically driven by needs of clients that are prefabrication or construction companies. The case product Deltabeam responded to the needs of easier and faster installations of technical systems, and flexibility in construction and operation phases. Ideas are also gotten from emerging material, construction, manufacturing and ICT technologies. Thus, innovations are driven by mixed market-pull and technology-push.

The innovative products of the company are usually such that their implementation in buildings requires a substantial input of own R&D resources as well as outsourced research-based services to verify the technical performance and facilitate product approvals. The patented case product Deltabeam could be implemented in the building projects only through national type approvals that were based on product-related research-based data and methods. The national type approvals have been a hindrance to access various markets, and a part of the competitiveness of the company is its knowledge about the various countries and building cultures. A valid patent does not necessarily inform about implementation of a product.

The prerequisites of the fast product launch and implementation in the building projects can be listed as follows:

- Innovation-orientation and encouragement of the founder of the company;
- Response to growing market needs (flexibility, productivity, long-spans);
- Quick creation of the R&D project, and substantial funding resources;
- Enthusiasm and commitment of the expert team to produce a challenging solution;
- Right combination of competences, creativeness, mutual trust inside the team;
- High-level experimental research facilities available;
- State-of-the-art knowledge available for design methods and software;
- Uptake of emerging technologies (composite construction, high-strength steel);
- National product approval procedures rational in respect to new products.

The continuous development of the manufacture, product and services has been of great importance for successful expansion of markets and establishment in Slovakia. The other product innovations support nowadays also the Delta-beam implementation such as beam-to-column joints and composite columns. The role of research co-operation has been fundamental in the successful innovation processes. The innovation environment of the country has supported growth-oriented companies.

Analysis of the innovation process

The innovation management has become systematic along the internationalization and growth of the R&D function and the company. It has resources for in-house work and administration. However, the essential ingredients of innovation capabilities such as trust, care, and encouragement existed already in the small company that facilitated transition from individual knowledge to organizational knowledge. The principles of

the founder about client- and profit-orientation, openness and respect of all individuals as well as continuous development are still valid.

The innovation process consists of five knowledge creation steps (Nonaka 1994, von Krogh at al. 2000): Sharing tacit knowledge; Creating a concept; Justifying a concept; Building a prototype; and Cross-levelling of knowledge. The collaboratively identified knowledge enablers of Peikko Group in each step are summarized in Table 2.

Table 2. Identification of the success factors of the Peikko Group's innovation process on the matrix of von Krogh et al (2000); the important cells grey.

Knowledge enablers	**Sharing tacit knowledge**	**Creating concept**	**Justifying concept**	**Building a prototype**	**Cross-levelling knowledge**
Instil a vision	--	Growth strategy as a basis. Strategic alliances.	Compliance with strategy and client needs. Analyses of competitors	Fitness to regulations, building processes and manufacture.	Publishing new openings for design methods and standards.
Manage Conversation	Headquarters close to plants; common restaurant. R&D staff in customer service; new employee in worker training. Job circulation between R&D and other functions.	Frequent formal R&D meetings. Frequent idea gathering. Awarding promising proposals. Foreign employees trained in Finland	Cross-functional brainstorming. Frequent stake-holder communication (clients, designers, architects)	Requirements management - end-use - downgrade - on-site technologies - design - regulation - transport - ecology	Stake-holder information and consultation (clients, designers, architects); Conferences
Mobilize Activists	--	Directors and managers. Face-to-face meetings.	In-house project team and invited experts.	Activities of own and outsourced expertise	Conferences, workshops, standards, social media
Create the right context	Memberships in professional & standardization organisations, and workshops.	International R&D function. "Invention policy"	Engagement of own and outsourced expertise	Verification - all aspects of requirements	Marketing, exhibitions, publications, news releases
Globalize local knowledge	--	--	--	--	Patents Standards CE marking// type approvals

DISCUSSION AND CONCLUSIONS

A longitudinal single case study on the Deltabeam solution of the Finland-based Peikko Group Oy was conducted in order to characterize an innovation process in the construction product industry. The information was gathered in semi-structured and non-directive interviews, and through background documents by two researchers. The preliminary findings were reported in a summary paper, and assessed together with interviewees. Later, the findings were assessed together with Directors of R&D

function and Product Management. Information about the innovation process of the company can be regarded as reliable thanks to several sources and cross-checking.

The company's innovation function has changed along growth of the company, and its current organisation is international and operates according to the strategy of company whereas the start was more intuitive. The knowledge assets of the company are remarkable comprising client and regulatory requirements in a big number of markets, know-how about manufacturing technologies and implementation of construction product to building projects and a mass-customised portfolio of products with knowledge-intensive services. The product innovations have required substantial inputs from research and testing organisations.

The concepts and approaches of Nonaka and his colleagues are usable to analyse the innovation process of a small- and medium-size company in the construction product industry, especially in the stage when a company has established its own R&D organisation and has a strategy to grow through innovations.

Aknowledgements

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