Making use of knowledge on the construction site

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Mistakes during the construction phase are very costly. Avoiding mistakes on the construction site and facilitating an efficient construction flow is recommended by many researches as a way of reducing construction costs. One way of dealing with this issue is by finding flaws and errors during the design phase. As buildings are increasingly complex with installation systems and demands for energy efficiency there is also an increasing demand for more knowledgeable personnel on the construction site. The construction personnel must comprehend how issues such as energy transfer, moist transfer, air-tightness, acoustic property, water protection etcetera is accomplished with efficient logistics, often in a lean construction environment. The different manufacturers and research generate much knowledge. In Sweden many attempts to accomplish systems for lessons learned and experience feedback have stranded due to the complex nature of the whole issue. Construction knowledge containers in the form of web-sites emerge both as company property and “publically available” sources.

This research investigates how the construction firms use knowledge management to be effective and competitive on the market. Through interviews and observations data has been collected to describe the strategy of Sweden’s three largest construction firms use knowledge management. Additionally a large regional construction firm and a smaller construction firm have been studied. Particular focus is on the construction site and how the workers on the construction sites are involved in the planning of work execution and how knowledge is made available in this process and how this influences the motivation and learning of the site organisation.

Keywords: Knowledge management, **work preparation**, **organising information**.

1. Lack of knowledge lead to mistakes

Studies of the effects of flaws and errors in the Swedish construction process indicate that these accounts for some 6% of the total production costs and that about 10% of working time is spent on correcting errors and reworking what has been done (Josephson & Hammarlund 1999). Portions of the errors were caused by deficiencies in the design work; such deficiencies include shortcomings in the knowledge available to those engaged in production. A considerable proportion of the errors can also be traced to difficulties caused

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by vagueness or imprecision in the instructions provided by the design team (Josephson & Saukkorpi 2005).

Construction firms are expected to conduct work at the construction site in accordance with agreed-upon drawings and specifications. The client expects this to be done in a professional manner, even if this is not explicitly expressed in the contract. The specifications and the contract are normally based on national standard reference frameworks. Basic workmanship and knowledge of the regulations applicable to building and construction work are essential pre-conditions for performing the work in accordance with the contract.

1.1 The knowledge situation on site

Those in charge of work at the site and others engaged in the practicalities of a construction project need adequate knowledge in order to carry out their work properly; moreover, they need to continuously update their working knowledge to keep abreast of the latest technologies (Persson & Bergh 2006). Typically, operatives on construction sites will receive at most some 4 hours of training a year, in contrast to their supervisors, who undergo about 40 hours of training a year. The education obtained in upper secondary school remains the most important component in the training of the majority of construction workers. When new methods and materials are developed, new knowledge is needed. In order to acquire the information needed at a construction site, the personnel (both management and operatives) should be provided with relevant information and be motivated to learn and generate such knowledge themselves (Persson & Bergh 2004, 2006).

Designers base their specifications on standard reference works and directions from suppliers, whereas site operatives (i.e., construction workers, craftsmen, etc.) almost never have direct access to information sources of this type. Any contact they do have with these sources is usually superficial, such as an introduction to such matters in upper secondary school (Persson & Bergh 2004). The individual's knowledge, then, is scarcely renewed although the standard reference framework may be updated continually. Knowledge concerning a task that has been completed can be of genuine help at a later time (positive feedback) and may result in a new and more effective approach to the task (Persson 2006).

In an effort to gain an understanding of how various tasks are actually performed by those who carry them out, 41 cases of task performance were studied (Persson & Bergh 2006). Compared a generic process model the results revealed that flows of information of the following types were usually absent:

- Information from a standard reference work being made available to the site operatives,

- Information from relevant legislation and building codes being made available to the site operatives,

- Information about labour safety regulations being made available to the site operatives, and

- Further education being provided for the site operatives.

1.2 Management of knowledge on site

The knowledge management of site operatives tends to be very much neglected (Larsson et al. 2005). As employment is in many cases contract/project based, many employers are not willing to invest in further training for the workers. This is further magnified by the nature of construction, with many specialised subcontractors constituting a temporary organisation on site (Persson 2006). Before starting any work, the site operatives and the site management usually discuss the planning and execution of the work (Persson & Bergh 2003). Although this could in principle lead to optimising of plans, sadly, the lack of adequate knowledge on the part of both workers and management could undermine efforts in this direction. According to project managers who were interviewed in a project performed in Uganda, the most important steps in improving productivity involve eliminating incompetence among supervisors and addressing the lack of knowledge and skills on the part of many workers (Alinaitwe 2006: see appendix III p 10).

The present system of knowledge management for the on-site personnel of construction companies (operatives, management, and supervisors) can be characterised by the following statements (Persson & Hansson 2008):

- The large numbers of errors occurring at construction sites (and the considerable costs that result) appear to be largely due to insufficient knowledge transfer on the part of the personnel involved.

- Information obtained from clients, designers, suppliers, and the contractor that could potentially further the knowledge development of the on-site personnel appears not to be well adapted to this purpose, or to be only partially suitable for it.

- A management function (process) supporting the system for knowledge development appears to be either poorly developed or missing entirely.

The flow of information to personnel at construction sites concerning how the tasks at hand can best be carried out is highly important for the development of knowledge of work procedures generally. With better knowledge of this sort, errors can be minimised or eliminated.

1.3 Aim, objectives, and methods

The aim of this paper is to investigate typical features of knowledge management systems for construction sites of both large and smaller construction firms and the construction sector.

2. Knowledge management system as support to the construction site

The knowledge transfer that takes place in a construction firm should be supported by a capable quality management system, as well as by the systems for cost estimating, time scheduling, and labour safety. The site operatives should possess sufficient knowledge to be able to demonstrate good workmanship, and to make effective use of contract documents, drawings, and specifications as the starting point for their work. They should also have the support of the site management and the firm's overall management system, being enabled to draw on lessons learned and knowledge accumulated.

The task of the knowledge management system is to direct, enhance, and coordinate knowledge development in the firm, using the relevant subsystems and ensuring that the knowledge needed to carry out the construction work is made readily available. A clear objective of the knowledge management system is to develop the knowledge of the staff in such a way that the conditions of each and every contract will be met and clients' requirements will be satisfied in an effective and professional way. Most construction firms are lacking effective approach to collecting and storing knowledge within the organisation, placing little emphasis on developing the competence of workers, however the attitude is slowly changing. The large numbers of errors made in construction work and the virtual lack of further training suggest that knowledge management, in whatever form it may be present, usually does not function well.

Individual site operatives should continually acquire new knowledge so as to maintain a satisfactory level of workmanship. A major part of the knowledge site operatives need to perform their tasks is obtained during their initial professional training and apprenticeship. Formal training provided after that is usually very limited. To be well prepared for the tasks they will perform, workers require ready access to further sources of knowledge, both general and project-specific. The following are certain important considerations pertaining to this:

- Drawings and specifications (in a form that the individual can readily comprehend) pertaining to the work at hand should be provided.

- A work execution plan (or detailed plan of the work to be done) should be made known, at the latest by the time the work gets underway.

- General descriptions of the work to be carried out should not only be accessible but also be easy to read and understand.

- There should be ample access to suppliers' instructions on how to assemble and use the materials and equipment involved.

- The laws and regulations that apply should be clear to everyone.

- Inspection routines should be clarified, and any checklist to be used for control purposes should be handed out to everyone.

The construction site knowledge management systems studied indicated the following problems for the individual site operative (Persson & Bergh 2004):

- Site operatives seldom attend planning sessions and toolbox talks regarding how work is to be carried out, even though they are the ones who perform the work.

- Only in exceptional cases do site operatives have the opportunity to read the specifications for the project they are involved in, or the relevant standard reference work.

- Site operatives rarely get to read the manufacturer's instructions.

- Drawings and specifications pertaining to work to be carried out often refer to standard documents or reference works or to instructions provided by suppliers. Such standard documents or reference works are usually not available at the work site.

- Construction workers are usually not trained to read standard documents or reference works. Although these may contain potentially useful instructions on how work is to be carried out, the instructions are often incomplete, out of date, or difficult to assimilate. The target groups for such documents are often designers and procurement personnel. Site operatives have little involvement with procurement and thus have limited access to these documents, and so such documents contribute little to the knowledge development of the workforce.

- Only in exceptional cases is a site operative encouraged or given the opportunity to reflect on, plan, or carry out the quality assurance work that is usually called for.

When looking at the resources used to do a project as according to Figure 1. The input to a project is the individuals and organisation of the construction firm, technology and equipment together with administrative procedures, checklists and templates. If these input resources are not present in the construction firm it has to be acquired from external sources.

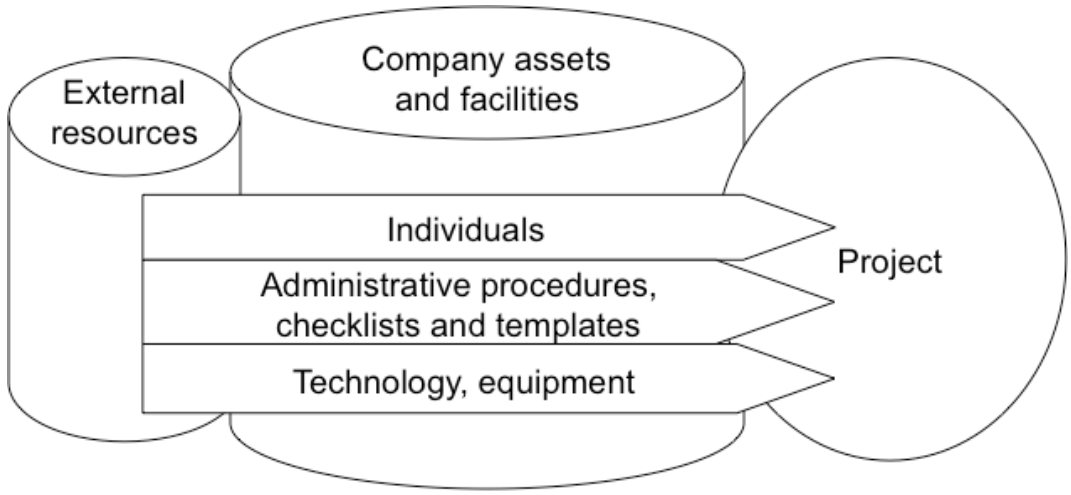

Figure 1: Company assets to accomplish a project.

The mismatch between subsystems and the lack of knowledge management can apply to different levels in an organisation. If one aims at changing practices in an entire construction firm, this must be undertaken at a variety of levels: individual – site – firm – national construction sector – international construction sector (Persson 2006).

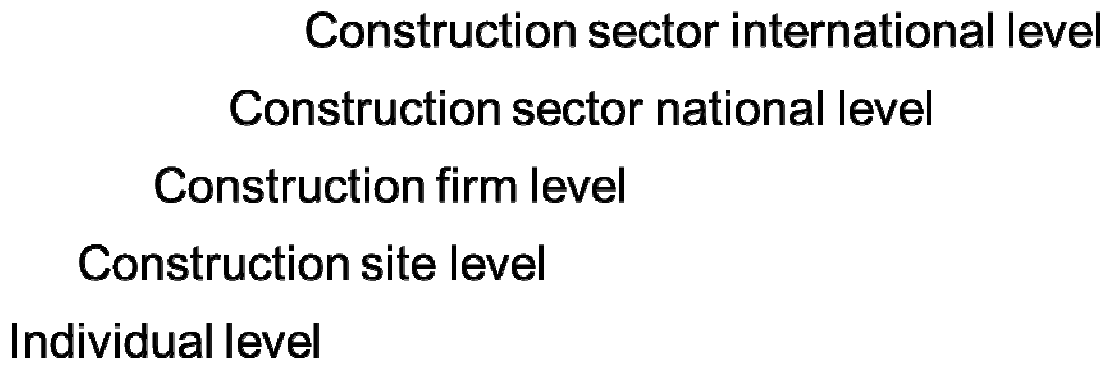

Figure 2: Levels for Knowledge management

The knowledge management of the sector and available information for personnel at the site is not well organised to facilitate a transfer from explicit to implicit knowledge according to the SECI model of Nonaka and Takeuchi (1995), as pictured in Figure 3. The bottom of the figure shows the process of socialisation (tacit → tacit); on the left is externalisation (tacit →explicit); at the top is combining of knowledge (explicit →explicit), and on the right side is the important process of internalisation (explicit → tacit). Enabling internalisation is the main objective of the development of http://www.ByggAi.se.

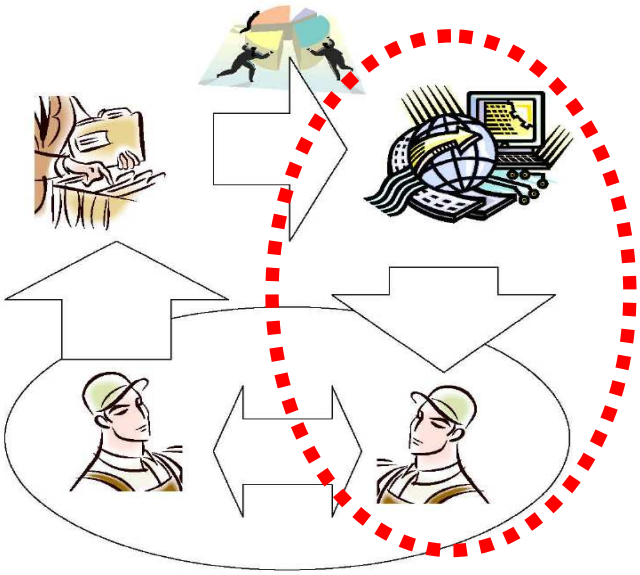

Figure 3: The SECI model of knowledge transfer with the process of internalisation highlighted (adapted from Nonaka & Takeuchi 1995)

3. Systems for improved knowledge management on construction sites

3.1 General system improvement

Various problems have been outlined concerning mismatches between subsystems within construction firms' knowledge management systems. There are various approaches that aim at suggesting, describing, or providing solutions to these problems. The Ratu file for planning construction (www.rakennustieto.fi) is one such attempt. This file is intended to improve the productivity, safety, and quality of construction work. Information regarding work procedures and work planning is collected at construction sites and is made available; information about safety in the workplace is provided, and quality assurance information is included. The file is available in a Finnish-language version only. In Denmark, knowledge about construction is gathered in a database (www.bygviden.dk). The program CITB Construction Skills is concerned with educational matters that apply to the entire construction industry (www.cskills.org).

3.2 Knowledge platform www.ByggAi.se

In Sweden an approach to making task-related information available as needed to those engaged in construction work has been developed in cooperation with various construction firms (Persson & Bergh 2006), the name of the system is *ByggAi.se*. The system has general site-use-adapted working instructions developed to transfer knowledge on site in a well-structured form. The basic information needed to carry out different types of work is readily available, with a focus on the needs of managers and operatives at a construction site. The working instructions contain information on personal safety, quality control, requirements, suggested tools and supplementary fixtures/materials, and illustrations and text describing suggested correct ways to carry out the work. The system makes information

available from health and safety systems, suppliers, standard reference works, and quality systems.

The instructions were designed in this way for the following reasons: The working instructions (WI) are general, meaning they can be used at most construction sites; this also means that when they are used they need to be supplemented with information specific to the project at hand. The WI's are site-use-adapted, meaning that they are adapted to the information requirements of the personnel conducting the work on site rather than the needs of purchasers, designers, etc.

During development a number of various methods for presentation of the WI's were investigated. Video, cartoons and written instructions were considered. A combination of pictures and short explanatory texts were chosen. The WI's are developed in PowerPoint and distributed in pdf-format. A format suitable for printing was selected and the pictures in the WI's turned out to serve as inspiration as they contain a lot of additional (surplus) information about the site and situation for the work. A reason for choosing pdf-format was the need to limit the size of files since at the time of development only few sites did have high-speed Internet access. Today a new format or alternatively database is investigated.

The development of the WI's was done in close cooperation with major construction firms in Sweden. The topics were selected among usual tasks on the construction site - work done on most sites. However a variety of topics were selected to include civil work as well as construction, rebuilding, demolition, HVAC and electrical installations, painting. Additionally there are a number of "informational" WI's developed to test the possibility to distribute information on working environment, protection against thefts, work in cold climate, transports on site etc.

The ByggAi system is available on the Internet at www.ByggAi.se. At this stage the Internet portal contains working instructions for 152 different tasks. For each set of instructions, the following main headings are used: Requirements, Preparations, Quality control, and Performance. The working instructions are available on the Internet portal in PDF format. A CD in PowerPoint format containing the working instructions, together with a template for those wanting to prepare their own working instructions, is also available.

3.3 The development of knowledge management in the Swedish construction sector

In Sweden around 300,000 employees work in the construction sector, which contribute to 8% of GNP. Investments are considered to be relatively low with difficulties to start new residential projects, however rebuilding is slowly increasing to the same level as new construction. The use of construction management software is slowly increasing in Sweden. On major construction sites the use of advanced software is spreading with utilisation of software for Virtual Design and Construction. Medium size and smaller firms adopt the use of iPad's and smartphones on construction sites in order to improve the distribution of information. This facilitates the distribution of information from the www.ByggAi.se web-site.

The ByggAi.se system has been well adopted by Swedish construction firms. The major contractors have designed their own internal knowledge management systems for their construction projects and link from their intranets to www.ByggAi.se. Smaller and medium-sized contractors use the system, as it is available on the Internet, or acquire the rights to use the information in their companies. Smaller contractors often say they would never be able to build such a system on their own. The system has recently been upgraded with a book on work preparation and teaching material and template available on the web.

The number of visits to the website is increasing. The number of visits per day has risen from 60 per day in 2009 to 149 in 2012. The first months of 2013 show a further increased number, now the average is above 320 visits per day. Positive feedback has been received from young engineers and also consultants such as architects. A couple of suggestions of needed corrections and clarifications have also been received.

The Swedish Contractors Federation has identified the need to improve knowledge management as a means to reduce errors and accidents on construction sites. They are now publishing a “Technical handbook for the construction site”. This handbook is divided in two parts. The first part contains information of what is well worth noticing when doing certain types of works. The second part contains information that is well worth knowing when doing construction project. The information of the handbook is connected to www.ByggAi.se with references and illustrations. It is also connected with references to the latest developments from research and development of techniques and tools. The handbook will be updated every year

4. Discussion and Conclusions

Currently there appear to be serious problems in the flow of information needed to provide adequate knowledge on how to perform tasks at construction sites. Inadequate knowledge leads to production problems on the construction site. Often, the same solution found for a problem concerning a given task at a particular site under a given set of conditions can also be applied at another site, even though conditions there may be different. There is thus a certain generality to the solutions suggested, which may basically apply throughout the construction sector.

The system – general site-use-adapted working instructions – ByggAi.se – thus addresses a wide variety of problems. Although ByggAi.se provides solutions to many problems, there is the question of the extent to which workers have access to it. Supervisory personnel at construction sites should either make computer facilities available to the personnel or make the instructions available to workers in a hard copy format.

Changing the way a given task is performed at construction sites within the entire construction sector as part of a movement for “continuous improvement” calls for a wide and open cooperation between those supplying information resources, contractors, clients, and others involved in the construction process. This also fits well with the analysing of construction activities being done in conjunction with lean construction.

From the SECI model it is important to acknowledge that the internalisation process is key. This has also been the focus of the research carried out to establish a platform that enables this process to start. The availability and ease-of-use factors are important, as is the need to avoid overloading the platform with information; rather, the idea is to make information readily available as it is needed ("Just what you need – when you need it"). The second most important factor in developing the platform is the combining process. This "background" work has been given highest priority as it is in the control of the platform developer (the internalisation process is practically beyond control).

References

Alinaitwe Mwanaki, H. (2006) Labour Productivity in the Building Industry. Lund - Sweden: Division of Construction Management, Lund University.

Arbnor, I., and Bjerke, B. (1997) *Methodology for creating business knowledge*. Second edition. London: Sage publications.

Birve, L., and Hansson, B. (2003) The Challenge! article (keynote speech) in Hansson, B., and Landin, A. (editors) *Construction Economics and Organization, Proceedings of 3rd Nordic Conference. Lund* - Sweden: Division of Construction Management, Lund University.

ByggAi - Website of Site-Adapted Work Instructions Internet: http://www.ByggAi.se.

CIBW78 (1997) Working Commission W78 workshop Information Technology Support for Construction Process Re-engineering, Cairns, Australia, July 9-11, 1997.

Josephson, P.-E., and Hammarlund, Y. (1999) "The causes and costs of defects in construction: a study of seven building projects", *Automation in Construction*, Vol. 8, Issue 6 pp 681-687.

Josephson, P.-E., and Saukkorpi, L. (2005) *Slöseri i byggprojekt - Behov av förändrat synsätt*, FoU-väst Rapport 0507, Göteborg Sweden.

Larsson, S., Lundin, L-Å., Ruden, J., Tilly, H., and Östlund, H. (2005) Satsa på yrkesutbildning (translated: Invest in vocational training), Sydsvenska dagbladet, June 28, 2005.

Nonaka, I., and Takeuchi, H. (1995) *The Knowledge-creating company*, Oxford University Press, New York.

Persson, M. (2006) *Lessons Learned in Knowledge Management – the case of construction*. ISRN LUTVDG/TVBP2006/1021--SE. Lund - Sweden: Division of Construction Management, Lund University.

Persson, M., (2012) *Planering och beredning i bygg- och anläggningsprojekt*. (in Swedish). Lund, Studentlitteratur, Sweden.

Persson, M., and Bergh, Å. (2004) *Förstudie - Upplärning med systematiska arbetsinstruktioner.* (in Swedish) ISRN LUTVDG/TVBP--04/3085--SE. Lund - Sweden: Division of Construction Management, Lund University.

Persson, M., and Bergh, Å. (2006) *Arbetsplatsanpassat lärande – rapport från utvecklingsarbete*, (in Swedish) ISRN LUTVDG/TVBP/2006/3087--SE. Lund - Sweden: Division of Construction Management, Lund University.

Persson, M., and Hansson, B. (2008) “Supplying Production Instruction Knowledge to the Construction Sites”. In: *Conference proceedings: Transformation through construction, Joint 2008 CIB WO65/WO55 Symposium, Dubai, United Arab Emirates*, 2008-11-14-17. Carter, K., Ogunlana, S. & Kaka, A., eds. School of the Built Environment, Edinburgh: Heriot-Watt University. pp. 158-159.