Developing and Managing Knowledge of Construction Methods in the Swedish Building Sector

Persson, M.
Halmstad University, Box 823, SE-30118 Halmstad, Sweden
(email: mats.persson@hh.se)

Abstract

In the 1960s and 1970s the construction industry made an effort to develop shared knowledge and performance measurement tools within the industry. This effort ceased as the bigger enterprises began to see information generated at their companies as enterprise assets and competitive resources. In recent years, the construction industry has begun to acknowledge the importance of detailed planning and work preparation on construction sites. The fragmentation of the construction process, with increased specialisation and involvement of many interested parties and actors calls for a shared format for creating, converting, and exchanging knowledge. There is a need for better documentation and control of what is actually done on the construction site, and of how it is done. The purpose of this paper is to discuss how knowledge about construction methods is created, converted, and shared in the Swedish construction sector. It examines past efforts to share information and how the efforts have developed over time. New initiatives are examined and analysed, looking at how well knowledge is managed and applied on construction sites. A web portal developed at Lund University (www.ByggAi.se) in close cooperation with the construction industry exemplifies a new initiative in this respect. The paper will also present end users' analysis regarding the accessibility of information from the web portal. The web portal has a great potential to disseminate information to various actors: construction enterprises, manufacturers, consultants, and clients. The web portal has also developed to include other areas of interest, promoting issues such as health, safety, and ergonomics; energy-efficient buildings; energy-efficient construction work; and handling of moisture issues. The main advantage of the portal is its packaging of situational knowledge, so that workers at all levels can find all of the relevant information about specific construction methods before they begin work on the construction site. Moreover, the portal makes the information available on a "just-in-time" basis, so workers can continue to access it throughout the project, taking what they need to know at the time they need it.

Keywords: knowledge management, workers' instructions, knowledge transfer, continuous improvement.

1. Lack of knowledge leads to mistakes

Studies of the frequency and 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 or planned (Josephson & Hammarlund 1999). A portion 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 by vagueness or imprecision in the instructions that the design team provides (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 (such as NBS in the UK and AMA in Sweden). 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).

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 and to propose a guide to improve the coordination of various components of such systems.

2. Problem analysis

A process model of flows of information, machinery, tools, and materials for tasks at construction sites is shown in Figure 1. The site managers prepare for the task, and the site operatives carry it out. The preparations include studying the drawings and specifications with reference to standard reference works and relevant information accumulated regarding the task at hand in the project organisation. There should also be some kind of check before the task is handed over to the next step in the construction process.

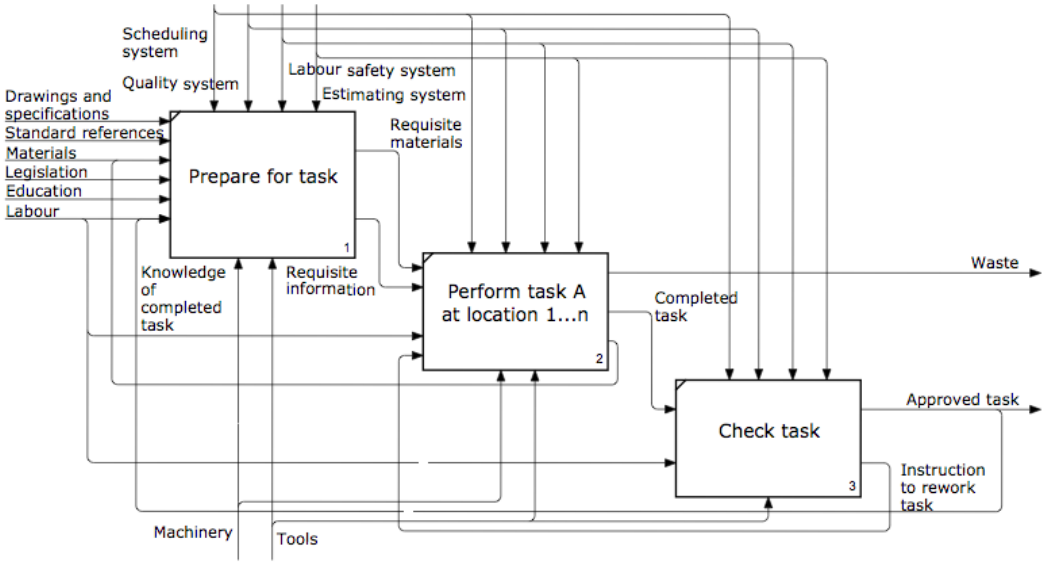


Figure. 1: A generic process model illustrating the flow of information and resources needed to perform Task A at location n on the construction site. (Adapted from CIB78 1997 by Persson & Hansson 2008)

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 of this sort were studied (Persson & Bergh 2006). Compared with the generic process model described in Figure 1, results revealed that flows of information of the following types were usually absent:

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

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

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

4. Further education being provided for the site operatives.

3. 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. In most construction companies, however, no explicit knowledge management system has been developed. Most take an ineffective approach to collecting and storing knowledge within the organisation, placing little emphasis on developing the competence of workers. 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):

- Planning sessions and toolbox talks regarding how work is to be carried out are seldom attended by site operatives, 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.

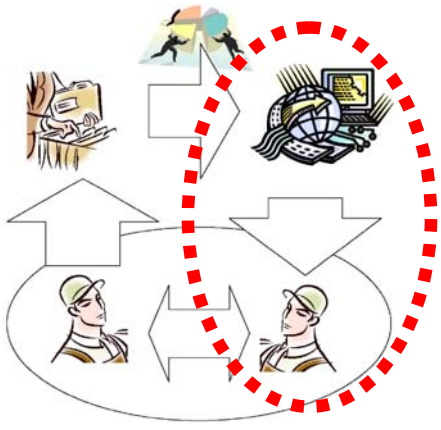
- Drawings and specifications pertaining to work to be carried out often refer to standard documents or reference works or to instructions provided by suppliers. Such standard documents or reference works are usually not available at the work site.

- 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 either 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.

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).

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 2. 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



www.ByggAi.se.

Figure 2: The SECI model of knowledge transfer with the process of internalisation highlighted (adapted from Nonaka & Takeuchi 1995)

4. Systems for improved knowledge management on construction sites

4.1 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).

4.2 Knowledge platform www.ByggAi.se

At Lund University 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 Swedish 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 WIs 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.

The ByggAi system is available on the Internet at www.ByggAi.se. At this stage the Internet portal contains working instructions for 127 different tasks. For each set of instructions, the following main headings are used:

Requirements – This section starts with Personal safety and health and describes risks and suggested preventive measures. Demands or recommendations from standard reference works and manufacturers' and suppliers' instructions are summarised.

Preparations – Contains checklists on basic prerequisites for the task. This includes equipment, suggested tools etc., various supporting material (fixtures) and suggestions on materials handling (deliveries, on-site transportation and waste handling).

Quality control – A basic form for registering quality control data is provided. Other requirements specific to each construction project need to be added.

Performance – Selected pictures accompanied by brief texts are provided, describing and presenting standard ways of carrying out the work in question.

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. Figure 3 shows example WI pages.

The ByggAi.se system has been well adopted by Swedish construction firms. The major contractors now work on 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 portal www.ByggAi.se was appointed “Innovation of the Year 2008” by SBUF (The Development Fund of the Swedish Construction Industry).

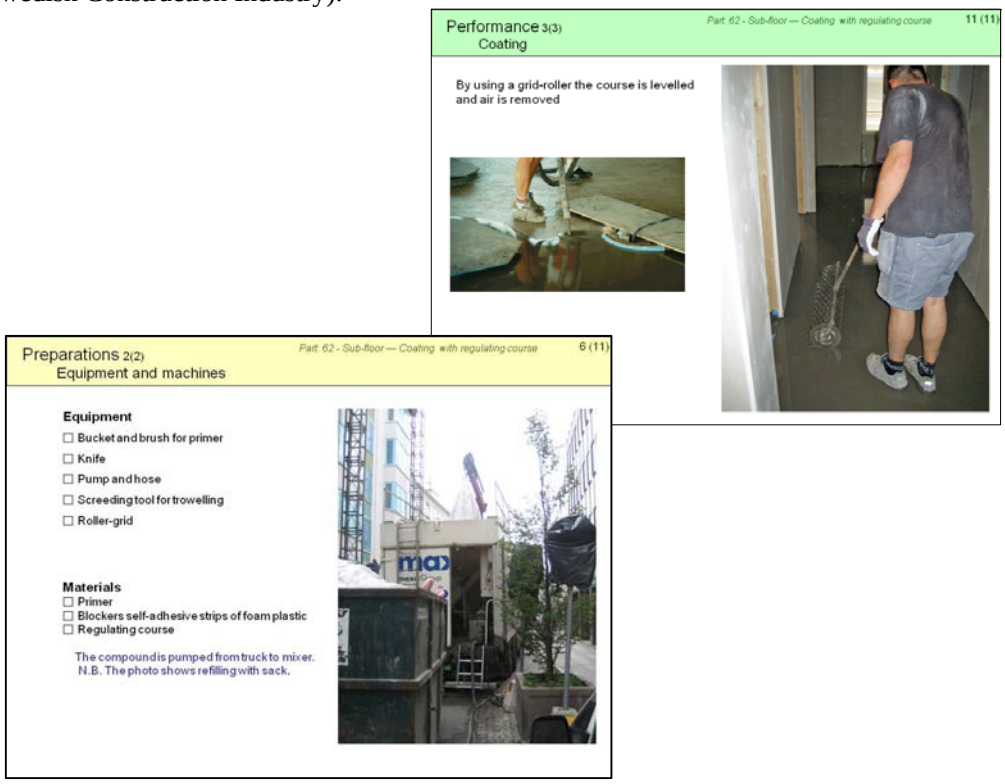


Figure 3: Example from Working Instructions of ByggAi.se (To date only available in Swedish, translated for this paper)

5. 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. The inadequate knowledge transfer leads to production problems on 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 – thus addresses a wide variety of problems. Although ByggAi 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. It is up to the supervisors to initiate meetings for the discussion of new tasks ahead of time. The best option, presumably, is to provide necessary information in a structured way at an appropriate time.

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).

The system of working instructions described here requires further development. First, the number of working instructions available needs to be increased so as to create as broad a knowledge base as possible. Also, various technical developments should be monitored to determine whether they provide new possibilities for the distribution and storage of information that could be useful here.

In addition, the effects of the working instructions should be further monitored and assessed in order to validate their use and to consider their further development. An indication that the ByggAi system is welcomed by the construction industry is that major Swedish construction companies have already started implementing this method of working and they agree that ByggAi is an important tool for the improvement work undertaken. Similarly, various educators have tried it out and found it to be useful.

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., and Bergh, Å. (2003) Planering *i bygg- och anläggningsföretag – framtagning av utbildningsmaterial*. (in Swedish) ISRN LUTVDG/TVBP--03/3083--SE. Lund - Sweden: Division of Construction Management, Lund University.

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: *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.