

SELECTION OF CONSTRUCTION WORK PROCESSES: CURRENT PRACTICES AND A NEW PROPOSAL

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Abstract

It is recognized that the Chilean construction industry has a lower productivity comparatively to other industrial sectors. One of the causes of this poor performance is the lack of efficiency and effectiveness of the work processes utilized to carry out construction work. According to a recent study, this situation is caused by the lack of adequate selection of construction processes that can deliver what is specified at the beginning of construction work. The objective of this work is to present the main findings of the study and to propose an approach, based on information and knowledge from past construction projects, for the design and selection of construction processes in new projects. The paper also describes an ongoing research effort that is being carried out with the goal of developing a knowledge-based management system for construction processes' selection. Thus, knowledge about current process selection practices is first presented and discussed. Second, a preliminary knowledge-based model for construction processes' selection and the general application methodology are described. The main conclusion is that Chilean construction companies do not make an appropriate design of their construction processes and a knowledge management tool is proposed to correct this inadequacy. The application of this tool could help Chilean construction companies improve their construction performance by better selecting and managing their construction processes as well as by procuring suppliers that can achieve the required performance. This approach can also be useful for construction companies in other countries.

Keywords: Construction; Information Technology; Knowledge Management; Process Improvement; Method Selection.

Introduction

The construction industry has a lower level of productivity and development as compared to other industrial sectors. Also, it has difficulties in the reaching of the quality standards required by clients (Tapia, 2007). The reason for this situation has been searched at the product level, the production level, and in the industry as a whole (Vrijhoef, Koskela, 2005). One of the causes of these problems is, according to some researchers, the use of inadequate construction processes (Poon et al., 2003). This is very relevant if we think that a construction company is only as effective as its processes are (Hunt, 1996).

A process can be defined as a collection of interrelated work tasks, initiated in response to an event, and achieving a specific result for the customer and other stakeholders of the process

(Sharp and McDermott, 2001). An important aspect of a process is its capacity, which defines the potential of the production system (Serpell, 2002). Then, it is important to understand the capacity of a process, since this will help to know if the process is or is not able to accomplish the specified requirements, or if it is necessary to change it.

In construction companies there are problems in reaching acceptable levels of quality. Also, there is an inefficient use of project resources caused by the lack of process quality management (Rodney y Clinton, 2006). Many quality and productivity problems on construction sites could be associated with an incorrect process design. This could partially explain why high levels of rework, underutilization of equipment, and budget overruns occur, among others. The design of construction processes is part of the project's production system design and considers decisions that range from who is to be involved and in what roles, to how the physical work will be accomplished (Ballard et al., 2001).

This situation creates a complex reality for improving the performance of construction companies, since the only way to do this is by producing a production system design that is "right at the first try" (Cooper et al., 2005). This is relevant not only in the product design but also in the design associated to the production system that will produce it. Despite its importance, usually very little attention is given to production system design in the construction industry (Schramm et al., 2006) and, in general, the project team will repeat what they have done on previous projects, but normally obtaining different results (Ballard, 2005).

According to Cooper et al. (2005), difficulties exist in producing and using construction production information and much information obtained from previous projects is not reused because it is not kept, due to the problem that appropriate mechanisms for doing so are not available in most of the companies. This is paradoxical; seeing that the construction industry is strongly knowledge-based and that experience plays a fundamental role in decision making, then wouldn't it be expected that the production and management of this information would be vital for business operation within the industry (Egbu et al., 2004).

Currently, most construction processes heavily rely on traditional means of communication, like face to face meetings and the exchange of documents in the form of technical drawings, specifications, and site instructions (Stewart, 2007). In addition, the information and knowledge created during the execution of a project are often owned by the project team and a lack of information and knowledge sharing becomes an important factor that affects the business performance (Wu et al., 2004). If experience and knowledge is shared and used appropriately, then the same or similar problems in construction projects would not need to be repeatedly solved (Tserng and Lin, 2004). These resources would improve the company's performance, and reduce the cost and the probability of repeated problems (Lin et al., 2006).

This paper presents the main findings of a study on construction processes oriented to understand how Chilean construction companies face the design of construction processes. Further on, the article proposes an approach based on the use of construction processes information and knowledge from past construction projects for the design and selection of construction processes in new projects.

Research methods

This section presents the methodology applied in stages one and two of this research. Stage one was carried out to understand construction process design practices in Chile, identifying features and limitations. Stage two is being carried out with the purpose of developing a support tool for construction processes selection. The main characteristics of this work and the proposed tool are elaborated in this section.

Construction processes selection practices in Chile

The main reason to do an exploratory research regarding the selection of construction processes was to understand why there are so many problems of inadequate processes selection in construction projects and to propose ways to improve this situation.

Research hypothesis:

- No formal methods are applied for the selection of construction processes that guarantee the required performance once they have been implemented by housing construction companies in Santiago, Chile.

Research Objectives:

- To develop a critical analysis of the construction processes selection practices in construction companies.
- To recommend a methodology for construction processes selection, based on the principles of process management.

The methodology used to do this research was based on the development of a survey to study construction processes selection practices in construction companies in Chile. The main stages of this methodology are shown in Table 1.

Table 1. Work methodology

Stage	Results
Study of the main concepts associated with construction processes selection	Theoretical framework for the development of the survey and the selection of the variables of the study
Pilot survey elaboration	Pilot survey
Pilot survey application	Verification of the correct design and construction of the survey
Pilot survey results analysis	Reformulation of the survey. Definition of the final version of the survey
Application of the survey to construction companies	Real information about construction processes selection practices
Analysis of the results	Diagnosis of construction processes selection practices in construction companies

The survey was obtained by interviewing the respondents (project managers and project supervisors). The final survey included 27 questions.

The population under study was housing (houses and buildings) under construction in Santiago, Chile. By that time (January 2007), the total number of projects was 544, including every project with a total construction area of at least 500 m². With this information, a statistical study of the sample size was carried out to determine the quantity of necessary surveys required for a valid study, as show in Table 2.

Table 2. Survey requirements

Kind of Housing Project	Population	Number of surveys
Houses	193	22
Buildings	351	38
Total	544	60

The survey was structured in three parts. The first part was concerned with the demographic information of the respondent, including aspects such as educational profile and position in the company. The second part of the survey was concerned with construction processes selection issues. This part had a forced-response format where respondents were required to select a response between five alternatives, according to a Likert scale. The third part of the survey was oriented to find out the value that people give to the documentation of their on site work.

The questions that were included in this survey were structured to measure 11 variables: existence of design methods, knowledge about design requirements, resource allocation, analysis of different construction methods, process capacity, process design, design validation, process control, planning, corrective/improvement actions, and documentation.

Development of a support tool for the construction process design

After the main characteristics of the construction processes selection practices were identified, different solutions to improve the performance of this activity were analyzed. The selected approach was knowledge management, due to the features of the construction industry, which are intensive in knowledge and experience, but lack standard procedures to use this knowledge. Also, an ongoing exploratory research on knowledge management in Chilean construction companies identified that these firms are very interested in this approach. In this way, the research question was defined as follows:

Research Question:

- How to obtain, process, store, and use a construction company's knowledge to select construction process that can attain specified requirements?

Research Objectives:

- To identify and understand the required knowledge to design or select construction processes.
- To develop a knowledge map for the design/selection of construction processes, defining all relevant variables for their analysis.
- To study and define the appropriate mechanisms for the acquisition of this knowledge.
- To develop a prototype system to acquire, process, recover, and apply knowledge regarding the design or selection of construction processes.

Research results

Results regarding construction processes selection practices in Chile

After application of the survey, the data collected was analyzed from the perspective of the different kinds of housing projects (houses and buildings) to establish current practices and identify relevant problems. Also, some complementary information was obtained from the interviews made by the respondents when they answered the survey. A summary of the findings of the survey is as follows:

- a) Awareness of the existence of different selection methods: in house construction projects, processes are elaborated based on previous experience. However, they are not always defined before the execution phase of the project but instead are analyzed “on the run”. In building construction projects, a common answer was that they do not design processes because the design was made a long time ago and projects of the same company are similar, so the same design could be used. In projects where a design process exists, the answers were similar to the ones obtained in the house construction projects. Also, it was mentioned that the selected design depends on the knowledge of the site professionals.
- b) Knowledge about processes requirements: in house construction projects, knowledge of process requirements comes from technical drawings, specifications, and available construction time, even though the first two are constantly changing. However, the most important requirement of all is the project budget. In larger projects, it was indicated that sometimes it is assumed that people are familiar with technical drawings and specifications, without any verification of this supposition. In building construction projects, respondents indicated that projects are controlled by their budget. With regard to the architectural drawings, respondents mention that these drawings are constantly modified, so the information obtained from them is not very reliable.
- c) Resource allocation: in house construction projects, when it is time to select equipment, the price is the most important factor to analyze. With regard to human resources, the supervisor selects the crew according to their capacities. In building construction projects, the main problem is the lack of an adequate procurement method. Today, there is a tendency to require materials from the supplier without an adequate analysis of the supplier’s experience or product’s quality.
- d) Different methods analysis: in both kinds of housing construction projects there is a clear conscience about the fact that there is more than one method to do the work and people try to find the best way to do it, usually by selecting the one that helps them to make an optimal use of project resources. However, people tend to use the same solution for different problems always.
- e) Process capacity: this is the least considered variable in construction projects and in almost all the projects an analysis of process capacity is not performed.
- f) Design: in both kinds of housing construction projects, in process design, or in the selection stage, there is no involvement from the people that play a part in the process. Generally, there are only one or two people in charge of this task and in few instances they will ask for the opinion of others. Also, there is a tendency to design very simple processes to avoid confusion.
- g) Design validation: generally, there is no pilot test or simulation of the process design, because this consumes time and resources.
- h) Control: In house construction projects, people only control the most important work packages. In the case of buildings projects, control is a constant task.

i) Corrective/improvement actions: in both kinds of projects, corrective actions are not very innovative. There is an interest in process improvements but because of daily work pressures there are not enough occasions for it, since there are more urgent things to do.

j) Planning: The most valuable planning tool is the bar chart or Gantt chart, although this chart is not always updated.

k) Documentation: In both kinds of projects there are three types of documents that are used in a regular way. These documents are technical specifications, architectural drawings, and project planning documents, the first two being the most important because they include project requirements. In second place are control plans, internal norms, and process control cards. In third place process execution procedures appear next to manufacturer's recommendations, and quality plans.

Finally, there was not a single project where all the variables were present. The ones that appeared more often were knowledge about process requirements, different methods analysis, and control and process planning. The variables that appeared the least were process capacity and process validation.

Development of a support tool for construction process design

Associated with the problems or deficiencies identified in the first part of this research, a preliminary proposal has been developed to face and resolve the problems associated with construction processes design or selection. This proposal is based on a knowledge-based model for processes' selection. The next paragraphs describe in this proposal and its main characteristics.

First of all, it is important to remember that construction processes, like any other type of processes, can be seen as a transformation function, as shown in Figure 1. Here it is possible to observe that for any process, it is necessary to identify the outputs that satisfy the requirements of the process product and to decide about the type of process that is needed to obtain the expected result, according to restrictions and inputs features.

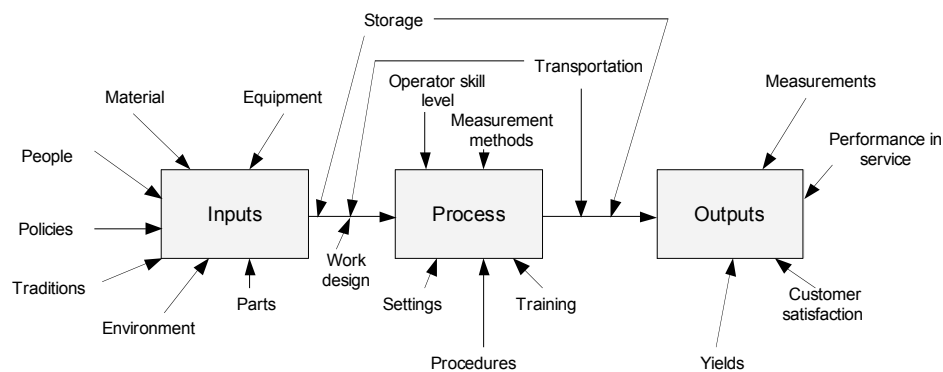


Fig. 1. The process as a transfer function (Pyzdek, 2003)

However, the physical production process of an organization generates an information flow or virtual factory of knowledge that runs parallel to the execution of the process that collects and builds information about processes and products to ensure both customer and shareholder satisfaction (Pearson, 2001). So, it is possible to observe that if we improve the knowledge flow within an organization, this adds value, increases the ability to compete, and helps to improve the quality and performance of future projects of the company (Al-Ghassani et al., 2006). From a

construction industry perspective, we could think that if construction companies count with an organizational knowledge base, and incorporate the knowledge and information obtained in the production stage of each one of their projects, they could use this previous experience to design new production systems based on processes previously used in the company allowing better operational decisions in this way. In this study it is considered that knowledge management provides the appropriate methods and tools to do this, as long as knowledge is managed in a systematic way.

Thus, whenever the company requires the design of construction processes (by simplification it has been assumed that the design includes the selection of processes as well as their adaptation) for a new production system, it will be able to support this procedure using a knowledge management system. Here there are three possible situations, (1) that in the knowledge base there is a process that totally satisfies the output requirements of the new production system and that is applicable to the new situation, (2) that in the knowledge base there is a process that partially satisfies the requirements but can be adapted to the new situation, or (3) that a process that reasonably satisfies the requirements does not exist, a reason why alternatives of previous processes in this case will not be available. According to the results of the search and selection of processes, the operational decisions to take could be: (1) to reuse a complete or proven solution, (2) to modify a previous solution or (3) to design the solution starting from zero. Later on, this solution will be applied in practice and checked in relation to requirements. The application of the process solution will generate new knowledge that will be incorporated into the organizational knowledge base so that it will be available in the future, allowing improvement and continuous correction of mistakes.

The action to search for processes in the knowledge base that would satisfy the process requirements is called process selection in this research. Thus, if someone wants to structure an effective production system, the appropriate process selection becomes an important factor for achieving that objective. It is important to underline that there is no interest in eliminating process design but to use the company's previous knowledge to facilitate this task. So, every time that a company needs to design its construction processes, it would not start their design from zero, because by applying the process selection approach, they would work on processes previously used by the organization, establishing a continuous improvement and learning system. On the other hand, a system like this would allow the development of a corporative memory, so that knowledge is not only possessed at the individual level but it is also shared and utilized at an organizational level creating the possibility of a sustainable competitive advantage (Chinowsky and Carrillo, 2007). The proposed knowledge-based model for processes' selection at company level is shown in Figure 2.

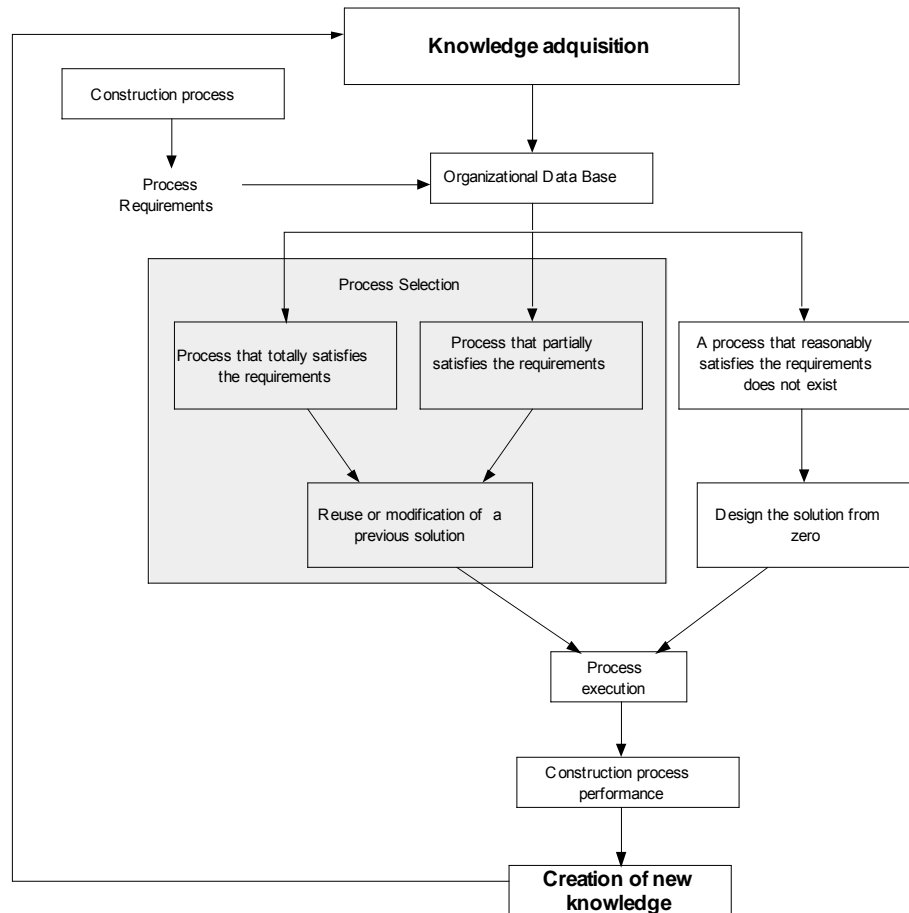


Fig. 2. Knowledge-based model for processes' selection

Discussion and conclusions

Chilean companies do not make an appropriate design of their construction processes, understanding by process design the selection of the input variables, the work flows, and the methods to carry out the production (Tapia, 2007). This is because not one of the projects analyzed worked with a structured process design procedure, a situation that affected their final results.

The main deficiencies found indicate that Chilean construction companies select and analyze their construction processes on the run as the project is being carried out, always choosing the same construction solutions in spite of knowing that there are other forms to carry out the work, and by supporting process selection on the knowledge of the professionals working on site. In this way they are selecting the simplest processes, not necessarily the best ones and without controlling the processes capacity. The problem with the process capacity analysis could be because of the inexistence of information about previous projects. The lack of this information could be associated with ignorance about their importance regarding good process design.

Another source of this problem could be associated with the fact that project managers place their trust on the process control activities to verify the results of process design, therefore they do not see the importance of a design that is right since the beginning, if they could fix the problems that appears in the future with corrective actions. Also some cultural problems appear, because people tend to do things in the same way they did it before, since if it worked in the past, it will work again. Obviously, they do not include in their analyses the cost of rework, or the delay in the

project program caused by the use of a design that is not adequate. Another problem is the lack of time that project managers have to report the problems and solutions that arise when a process is executed, since they use this time in what they consider to be more important tasks.

This situation causes companies not to transmit the knowledge that they acquire in each one of their projects, since this knowledge stays with the workers. A reason for which when a team member leaves the company, they take a part of the organizational knowledge with them. In addition, the same designs are use again and again without considering the problems that happened in the past, producing the same mistakes that are repeated, this agrees with other authors' findings (Wu et al.2004; Tserng and Lin 2004). It is hoped that through a better use of an organization's knowledge, the deficiencies already mentioned can be overcome..

Therefore, from a construction industry perspective, it is proposed that if construction companies count with an organizational knowledge base, with the knowledge and information obtained from the production stage of each one of their projects, they could use their previous experience to design each new production system based on processes previously used in the company and allow for better operational decisions in this way. In this study it is considered that knowledge management provides the appropriate methods and tools to do this, as long as knowledge is managed in a systematic way.

This study hypothesizes that by using construction processes, information and knowledge from past construction projects, the design and selection of construction processes can be greatly improved. An initiative like this could reduce the time and cost of solving problems, increase process quality, and diminish redesign activities, among others.

Key Lessons Learned:

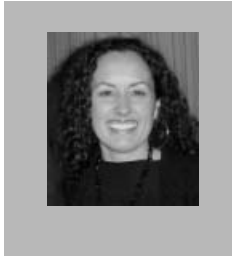
- Chilean construction companies do not make appropriate design of their construction processes.
- Project managers prefer to fix a poorly designed process instead of using a better design for the first time.
- Within the same construction company, knowledge about processes design is not shared because there are no available systems to do so.

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