

Integrated Process-oriented Selection Method for the most efficient Construction Techniques

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Abstract

The choice of appropriate construction techniques is a core competency of construction companies and will have a very important impact on efficiency and effectiveness of the work and the costs involved. Due to the short bidding period and work preparation time before work on site has to be commenced, and due to missing systematic decision making tools, the selection of construction techniques is done mainly by experience and subjective calculation of the project even for major complex projects. This does often lead to non-optimal processes during the construction phase. Resulting from this generally accepted practice, construction companies are frequently reluctant to consider new and innovative construction techniques, in particular, or they reject them totally for reasons of lack of experience. Practice has shown that adherence to tried and "trusted" construction techniques is making it very difficult for new, innovative and better-performing construction techniques to break into the market. Given the far-reaching commercial consequences of selecting the optimal construction technique, the Institute for Construction Engineering and Management at SFIT Zurich has initiated a research project aimed at providing a tool for practical application that allows a process-oriented, risk-based selection of the construction technique with particular focus on the impacts of the same on the overall construction process.

Keywords

Construction technique, process-oriented, risk-based, selection method

1. Introduction

1.1 Initial Situation

An analysis of the economic situation of the construction industry in Europe clearly reveals that the majority of companies have been generating operating margins in the range of +/- 0 for many years now. The North American and Asian markets are showing similar trends. The primary cause for this ruinous development is the lack of any differentiation potential among the companies and the associated competitive situation (UBS Outlook 1999), whereby contracts can only be won on the basis of pure price competition. This

situation is forcing construction companies to exploit any and every means of optimization. Cost-effective means of optimizing the primary cost factors involved in performing construction works (materials, equipment, wages) must be defined in order to develop an effective approach. As Fig. 1 reveals, the truly cost-effective means of optimization lie in a process-oriented and risk-based system selection model that has a direct impact on the equipment and wage costs.

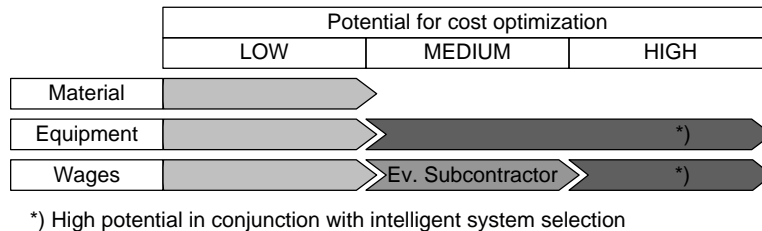


Figure 1: Potentials for cost optimization

1.2 Problem definition and background

The project specific and process orientated choice of construction techniques has a very important impact on efficiency and effectiveness of the work and the costs involved. The selection of construction techniques depends on the core process as well as on the parallel and sequential construction processes of the individual building. Depending on the time schedule, these processes are interacting with and depend on the parallel and sequential activities to achieve the goals. Due to the short bidding period and work preparation time before work on site has to be commenced, and also due to missing systematic decision-making tools, the selection of construction techniques is done mainly by experience and subjective calculation of the project even for major complex projects. But this does often lead to non-optimal processes during the construction phase with non-value added activities and inefficient performances by value added activities and processes, because the process as a whole is not interactively coordinated.

The consequences of this unsatisfactory selection procedure are:

- sub-optimal selection of the construction technique in regard to performance;
- failure to identify the full implications of the chosen construction technique for the overall construction process in regard to parallel and sequential processes;
- obstruction of new, innovative construction techniques;
- delays in introducing new, innovative construction techniques to the market;
- obstructions to development;
- commercial losses (both for the construction companies and the client);

Once the impacts of inadequate system decision-making processes have been defined, the following issues need to be addressed in order to identify the overall problem:

- At what point in time were the systems decisions made that are of genuine strategic relevance?
- How much time is available for the decision-making process?
- How much scope is subsequently available to correct incorrect system decisions, and what are the associated impacts?

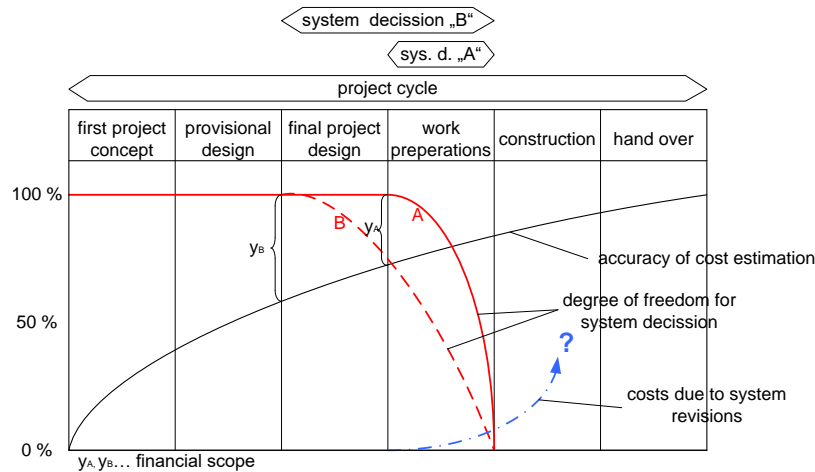


Figure 2: Possible phases of system decisions and their cost-effectiveness

Case A: “Classic case”: The system decision is made during the work preparation phase. This decision-making phase is already too short. The ability to influence project costs is already very limited, given the lack of any possible means of planning adjustment.

Case B “Early system considerations”: The choice of the most suitable systems is incorporated into the planning phase already. This extends the decision-making phase accordingly. Planning can be modified in line with the commercially most viable systems. As such, the ability to exert positive influence on the project costs is correspondingly larger.

However, any planner looking to focus on these matters at an early stage will be lacking the expertise of the company performing the works, since the contract will not yet have been awarded. If the system decision is made during the work preparation phase, then the time for conducting comprehensive analyses of the system options using conventional manual methods, is already short. The aforementioned clearly reveals that automated aids are the only means of conducting a process-oriented system selection.

1.3 Approach

This research project aims to use pre-structured process models to enable decision-makers to select systems based on their knowledge of the impacts of such systems on the overall construction process (PRSM: Process oriented Risk based Selection Method). This represents a total change from the former observation of partial processes, which were generally seen in isolation as a result of inadequate tools, to a complete link-up of all partial processes and, as such, to an integrated study of the technical and commercial impacts of individual system decisions.

The development of PRSM basically comprises two large areas of work focus. On the one hand, there is the modeling of building structures to enable the geometric conditions to be taken into account, whilst the other area necessitates the definition of systems, the partial processes, their interrelationships with each other, and the ensuing interferences.

2. Development of PRSM

2.1 Procedure

Following in-depth market analysis focusing on the approaches to dealing with strategic decision-making issues during the bidding and work preparation phases, intensive literature research was conducted with the aim of finding information about automated decision-making models. Fundamental methodical approaches were found in the work by Mawdesley (2002).

Since the works conducted so far only reveal elementary principles, or do not focus on the overall problem as a whole, a basic specification had to be drawn up for a first model construction which then served as the basis for setting up the model. So far this model has been developed to the stage where it can simulate the impact of system decisions during the construction process, and the results of the simulation stand up to logical examination.

The next phase of development plans to expand the scope to include the possibility of making risk-based decisions.

2.2 Scientific methodology

Constructivism is the primary research method used to develop this decision-making model, since it designs systems based on the intended input-output effect.

The theory-based structure of the model is derived from a logical approach based, firstly, on scientific mathematical methods, such as workload, cycle and cost calculation, and, secondly, with regard to the calculation process on the simulation of fuzzy variables.

Triangulation is used to ensure validity and reliability, on the one hand by means of the theory-based scientific structure, and on the other hand by the realizability test performed on construction projects of the companies involved in the research project.

2.3 Method of resolution

2.3.1 Modeling of building structures

Modeling aims to transform building structures, where the planner has defined the dimensions, into a geometric model allowing a systematic, standardized further processing of the same, i.e. simulation of the manufacturing processes. Depending on the type of structure, the modeling requirements vary considerably. The possibilities are demonstrated using a multi-story building with a reinforced concrete frame construction.

2.3.2 System definition and system combination

The primary system decision to be made when erecting multi-story reinforced concrete frame buildings is the choice of individual formwork systems for the principal construction elements. The further integration of various individual systems is based on a short, concise definition of the system characteristics and possible problems where they interface with other systems.

To define the possible system combinations a matrix was drawn, which reveals which system combinations are relevant for practical application. This matrix offers the framework for all subsequent considerations with regard to possible areas of conflict at system changeover points.

2.3.3 Definition of interactions

The interactions are evaluated on the basis of the following criteria:

- Constructive interdependency
- Geometric interdependency
- Temporal interdependency
- Logistical interdependency

2.3.4 Performance- and cost calculation

To quantitatively evaluate the interactions, the cycle times performances for the individual modules, taking in the account the influences at the interface points, are calculated. The costs are calculated automatically based on the performance calculation, with the program accessing databases containing the relevant basic data for the detailed calculation of the wage, material and equipment costs.

2.3.5 Risk assessment

The risk model is being developed using the constructivist research approach (developed by Piaget (1973), von Glasersfeld (1998) and Girmscheid (2004)).

The cost bandwidths and the relevant density allocations of the individual elementary processes are incorporated into the program in the next phase of development. Inputting the essential parameters in the form of expected values together with their upper and lower limits would be conceivable.

The ensuing result is a bandwidth of the possible costs combined with the degree of likelihood of their occurring.

2.4 Results

The following findings emerge from this research project:

- Demonstration of the implications for the overall construction process
- Demonstration of the commercial impacts
- Demonstration of the execution risks

3. Conclusion

Studying the range of available system combinations for the example of a high-rise building with a reinforced concrete frame construction makes it very clear why an aid to systematic process-oriented system selection is needed (Tab.1).

Table 1: Feasible process combinations for a high-rise building

	System combination	Construction cycles	Process combinations
technically possible	1380	12	16500
commonly used	96	4	384

Even if only the system combinations most frequently used in practice were to be examined during the bidding or work preparation phases, there would still be 96 various system combinations for each possible construction cycle. This figure alone clearly shows that selecting a system using “conventional” methods, i.e. manual processing, can only encompass a fraction of the possible system combinations. Moreover, the interaction between the individual systems can be captured neither qualitatively nor quantitatively.

The use of PRSM guarantees that process flows, structured once on the basis of tried and trusted experience, can be applied systematically to new projects, and that the pre-structuring of the total process flow, even for very complex tasks, can be used to identify optimal solutions. Moreover, the PRSM model can also be used to simulate parallel shell and interior construction works.

4. References

- Girmscheid, G. (2004) Ausführungs- und Angebotsmanagement – Leitfaden für Bauunternehmen, Springer Verlag, Berlin (GER) 2004.
- Glasersfeld, E.v. (1998) Radikaler Konstruktivismus: Ideen, Ergebnisse, Probleme. 2. Aufl., Surhkamp, Frankfurt a.M.
- Mawdesley, M.J. et al. (2002): A model for the automated generation of earthwork planning activities.

Piaget, J. (1973) Erkenntnistheorie der Wissenschaften vom Menschen: die Wissenschaften vom Menschen und ihre Stellung im Wissenschaftssystem. Ullstein, Frankfurt/M.
UBS Outlook (1999) Construction Industry, issued by UBS AG, Zurich.