

Construction Technology 2000

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KEYWORDS

Technological innovation, Technological forecasting, Organization of the construction process, Changing roles of process participants.

ABSTRACT

During 1984 and 1985 an extensive study has been made, concerning technological developments which are or can be of importance for the construction industry. The study was made on the request of the Committee of the European Communities, in order to determine methods to improve the competitive position of the EEC-construction industry in the internal market (i.e. within the EEC) as well as in the external market.

In this study a great interdependency has been established between the possibilities for technological innovations and the organization of the construction process. Based upon this interdependency, three alternative scenarios were developed, concerning the technology and the organisation in the construction industry in the year 2000. Two determining factors appeared to be of crucial importance: the amount of consensus about the division of tasks and responsibilities in the construction process and the way this consensus will be achieved.

The possibilities for the construction industry to maximize the profitable use, offered by the various new technologies, differ per scenario. Also the amount of influence of each process participant on the final product differs greatly per scenario.

Due to the fact that the market situation and the priorities in national innovation programmes in most Western industrialized countries are much the same, the results of this study can easily be adapted to countries from outside the EEC.

Technologiques du bâtiment 2000

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MOTS CLEFS

Innovation technologique, Prospective technologique, Organisation du processus de bâtiment, Rôles changeants des participants des processus.

SOMMAIRE

Pendant 1984 et 1985, à la demande du Comité de la Communauté européenne, une étude profonde a été effectuée sur les développements technologiques principaux dans l'industrie du bâtiment. Le but de cette étude était la détermination des moyens d'améliorer la position compétitive de l'industrie du bâtiment de la CEE dans le marché communautaire et dans le marché mondial.

Les enseignements de cette étude font apparaître une relation interdépendante entre les innovations technologiques et l'organisation du processus du bâtiment. On peut dériver de cette relation interdépendante trois scénarios différents, relatif à la technologie et l'organisation dans l'industrie du bâtiment à l'horizon 2000.

Deux données fondamentales se sont avérées dans la recherche d'une solution: d'une part le degré de concordance à réaliser dans le processus de construction sur le partage des tâches et des responsabilités et d'autre part la manière pour aboutir à cette concordance.

Chaque scénario démontre une réalisation spécifique pour permettre une exploitation au profit maximum des technologies nouvelles ainsi que l'influence différente de chaque participant au produit final.

Étant donné que la situation du marché ainsi que les priorités de l'innovation national se ressemblent dans la plupart des pays industrialisés de l'Ouest, les résultats de cette étude sont applicables également en dehors de la CEE.

1. INTRODUCTION

Due to demographic limitations as well as economic developments the total amount of construction activities in most Western industrialized countries has diminished for some years, causing a growing competition. Additionally new needs are becoming more dominant, such as the increasing interest in urban renewal activities, the growing importance of constructing energy and maintenance efficient houses and utility buildings, the need for a maximum of flexibility in constructions by the interchangeability of components, the rise of the so-called "smart buildings" etcetera. Because of those new needs the quality of constructions has become more important. However at the same time there is a strong demand to reduce the costs of construction.

Taken all this into account, the need to rationalize the construction is preponderant. One way to realize this is the application of a new generation of technology, in order to industrialize the production. The basic technology to achieve this is for the better part already available. The major problem therefore seems to be more one of commercialisation, introduction and application, rather than one of basic research and development.

Another major motivation for introducing much effort into technological innovations can be found in the world construction market. The competition in this market has recently become more fierce, partly due to the strong decline of the total production volume and partly due to the entry into the world construction market of a number of new competitors, to be more specific the recent rise of the New Industrialized Countries -NIC's- in (South) East Asia.

Ten years ago the construction industry in the Western European countries and in the U.S.A. still had a strong technological lead on these competitors. However, the present situation shows that in many sectors of construction the Japanese exporters have taken over this lead, while the South Koreans already have reached the same level as the Americans and the Europeans. Meanwhile the NIC's are also rising their level of technology in an alarming speed. Only with a lot of effort put into technological innovation this development could be countered, otherwise the Americans and Europeans will have to face a further diminishing position, which they will not be able to compensate during the next decades.

2. INTERNATIONAL TRENDS IN TECHNOLOGICAL INNOVATION

An analyses of national R&D-programmes on technological innovation in the construction industry in a number of Western industrialized countries has shown a great amount of similarity on long-term tendencies and priorities. The following four major trends in technological innovation can be distinguished:

1. Innovations related to **techniques and materials**, concerning development and introduction of new construction materials and products, tools and equipment and also new construction systems and

methods. This category of innovations has always been "standard practice" in the construction industry. However, for several years a new drive has been given to these innovations in order to obtain solutions for a substantial energy conservation, for an improvement of the health and safety situation during construction and lately also to meet environmental requirements. The most important driving factor developing and introducing new techniques and materials remains however the necessity for a substantial cost reduction.

Each of these innovations will in general result into only small changes in the characteristics of construction. These changes will mostly be limited to just one aspect of the construction process or to just one discipline and will seldom influence the construction process as a whole.

2. A more substantial improvement is the change in **production technology**, already introduced more or less hesitantly in two areas.

Firstly there is the rising use of prefabrication of construction components, to which recently a new dimension has been added by the prefabrication of interchangeable and/or large sized, integrated components. This last development necessitates new points of departure in design and in the execution of construction projects. Secondly there is the tendency to make more profitable use of high advanced technologies in the production of construction components, which are already in use on a broad scale in some other branches of industry. Examples of these technologies are systems for Computer Aided Manufacturing -CAM-, Flexible Production Automation -FPA- and the application of sophisticated Robots.

Although the actual application of these production technologies is mostly limited to the supplying firms, the consequences will be felt by all process participants.

3. Improvement of the quality of **design and construction management** by aid of the computer. Being more or less separate clusters of technological innovation there can be mentioned the development and introduction of systems of Computer Aided Design -CAD-, Computer Aided Management On the Side -CAMOS- and Computer Aided Communication -CAC-. This last technology handles about communication and information transfer between the various process participants and on branch level between companies and organizations by means of data-systems.

A maximum profitable application of the CAC-systems, and to a lesser extent also of CAD- and CAMOS-systems, will only be possible when all process participants involved are forced in one way or another to utilize standards for information transfer procedures.

4. Improvement of the overall efficiency of the organisation of the construction process by the **integration of computer subsystems**.

This technological trend could be regarded as an integrating factor between the innovations in the areas of Design and management on one hand and in Production on the other. A directed integration of the various computer subsystems could result in a practical link between design and execution of projects and production of components. In doing so, this trend could lead to a solution for the strong

segmentation between these areas of construction, that has hampered the construction industry for so long time.

More or less explicitly these four major trends could be recognized in all analysed R&D-programmes. However, also in most of them a striking lack of internal co-ordination could be observed. In each of the four areas the co-ordination of R&D projects was relatively strong but it failed between the areas as a group. An overall philosophy, that could serve as a guideline for each single innovation, was not apparent. The possible surplus value by an effective synthesise of these new technologies throughout the construction process can therefore not be expected.

3. DEPENDENCY ON PROCESS ORGANIZATION

The actual introduction and application of most of the new technologies, as mentioned before, concern more than just one process activity. By example, with the CAC-systems a maximum profit can only be obtained if the process participants involved can agree to the form of information and to the concerning information transfer procedures. To a more or less extent it can be stated that for all new technologies in the areas of Design and management as well as Production technology and Integration of computer subsystems, the possibilities for introduction and application therefore depend on the organization of the construction process. Based on an analyses of this dependency it can furthermore be stated that the present, highly segmented organization of the construction process is one of the most important obstacles for the implementation of technological innovations which are so necessary in order to rationalize and industrialize construction activities.

However, the relation between technological innovation and process organization will also act the other way round. The introduction and application on a wide scale of the concerning new technologies will sooner or later change radically the process organization. Taking into account the present computer-related developments in the construction industry, it can be expected that they will have enough momentum to change the process organization in a relatively short term.

4. THREE SCENARIOS

For the technology and the process organization in the construction industry in the year 2000, three alternative scenarios were developed. The following aspects were taken as a starting point for these scenarios:

- basic technologies that are already available or will be so in the near future;
- general accepted patterns about the expected evolution of the market needs in the various home markets and in the world construction market;
- the feasibility of each new technology in the future market needs, based on both technical and economical values;

- the two-way interdependency between technological innovation and the organization of the construction process, as has been described in paragraph 3.

Analyses of these aspects showed the great influence of two factors on the feasibility of the three alternative scenarios. The first decisive factor concerns the amount of consensus between the participants in the construction process about the division of tasks and responsibilities. The second factor concerns the way at which consensus can be achieved. This consensus can be the result of general agreements on the process organization, established by the branch institutions and if necessary supported in this by governmental bodies. This consensus can also be the result of a dominating position of one of the process participants, in such a way that he has the power to enforce a certain form of process organization on all other participants.

The analyses resulted in three scenarios which are shown in figure 1 and will be described further on.

Figure 1.

Three alternative scenarios

Consensus Inter- ference	Yes	No
Yes	"Consensus by agreements"	"No consensus"
No	"Consensus by force"	"No consensus"

Scenario 1. "Consensus by agreements"

A situation in which the tasks and responsibilities of all process participants can clearly be established by a number of agreements on the preparation and execution of all construction projects, with possible some separate adaptations per category. This set of agreements can be established as a result of an interference on branch level by the concerning branch institutions, if necessary supported in this by governmental institutions. It will be clear that this kind of consensus necessitates the full co-operation of all process participants.

Scenario 2. "Consensus by force"

In this situation the division of tasks and responsibilities of all process participants is the result of a dominating position of one of the participants. This position of force can be obtained due to the functioning of the free market mechanism, making it possible for one of the process participants to re-organize and adapt the whole process to his own specific wishes.

Scenario 3. "No consensus"

A situation in which one or more of the process participants in the construction process renders it impossible to co-operate and to communicate at an optimal way. As a result of this unwillingness the tasks and responsibilities of each participant are ambiguous and as a result the continuing strong segmentation between design, execution and production will prevent the construction industry to come to a more integrated approach.

It can easily be concluded that this last scenario characterize in general the present situation of the construction industry. Only slowly the construction industry is growing towards a situation of consensus, with tendencies towards "Consensus by force" (with a general contractor with the final responsibility, respectively with the general contractor "in force"), as well as tendencies towards "Consensus by agreements" (for example through experimentation with forms of Dimensional Co-ordination and with alternative forms of tenders, based on Performance Specification).

5. PROFIT FROM NEW TECHNOLOGIES

The application of the new technologies in the areas of Design and management, Production and Integration of computer subsystems depends on the form of organization of the construction process. Therefore the possibilities to apply the various new technologies are different in each of the scenarios. Figure 2 shows a review of the extent to which the construction industry will be able to maximize the profitable use of the new technological potentials in each of the scenarios, distinguishing maximum profit as (++), good profit as (+) and poor profit as (-).

Figure 2.

Extent of profit from new technological potentials

TECHNOLOGIES SCENARIOS	Design and management			Production					Integration of computer subsystems
	CAD	CAC	CAMOS	Prefabrication		Technologies			
				Exch. comp.	Integr. comp.	CAM	FPA	Robots	
Consensus by agreement	++	++	++	++	++	++	++	++	++
Consensus by force	++	++	++	++	+	++	+	++	+
No consensus	+	-	++	+	+	+	-	++	-

In figure 2 the following results of the analyses are taken into account:

- The profit of those new technologies, of which the application is in principle restricted to just one process participant (CAMOS and Robots), will not or only to a small amount be influenced by the different scenarios;
- The profit of those new technologies in which more process participants are involved in the application (CAC, FPA and Integration of Computer Subsystems), is very much different in each scenario;
- The profit given by new technological potentials in general is a lot higher in both Consensus scenarios than in the scenario "No consensus". In the scenario "Consensus by agreement" it is slightly higher than in the scenario "Consensus by force".

6. CHANGING ROLES OF THE PROCESS PARTICIPANTS

Comparing the scenarios it will be clear in which direction the construction industry should best adapt its organization. However, the interest of the construction industry as a whole is not, and in some situations not at all, the only most important motivation for each process participant. His own interest may be more important. In this context figure 3 shows a review of the inclining or declining involvement of each process participant, distinguishing a great (++) or small (+) increase and a decline (-) of involvement as an independent party in the process of decision making.

Figure 3.

Changing involvement of the process participants

SCENARIOS PROCESS-PARTICIPANTS	CONSENSUS BY AGREEMENT	CONSENSUS BY FORCE			NO CONSENSUS
		principal "In force"	architect "In force"	contractor "In force"	
Principal/client	+	++	+	+	0/+
Architect	-/0	+	++	-	-/0
Contractor	+	0/+	0/+	++	0
Supplier	+	+	++	++	+
Government	-	-/0	-/0	-/0	0/+

In figure 3 the following results of the analyse are taken into account:

- The principal will become more and more involved in the decision making process in all situations of consensus. This will also be

- the case in the social housing sector where the inhabitants will become more and more involved to express their wishes;
- The role of the architect as an independent party is the most sensitive one for the expected organizational changes in the construction process;
 - The role of the general contractor will become greater in all situations of consensus. In this context it must be expected that specially the role of the side manager will become more important;
 - In all probable future situations the supplying firms will gain influence in the process of decision making;
 - In all consensus situations the regulating and controlling role of the government will be decreasing.

7. NEW THREATS AND OPPORTUNITIES

The future will bring new threats and new opportunities to all participants in the construction process. With a possible exception for the largest firms, most firms in the construction industry are not known to have their policy making being influenced by long-term planning. However, the results of this study indicate that this attitude may prove to be fatal. If the fundamental changes as indicated in this paper, will not be anticipated, the firms involved are threatened to loose further their share of the market. However, this threat will not only be limited to those individual firms. It will also have its effect sonner or later on all branch levels in the construction industry. Therefore the concerning branch institutions will have to take an initiative to realize an improvement in strategy. As has been shown in this study the need for an overall consensus is preponderant.

Design of a Data Base for Housing Performance Requirements

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KEYWORDS

Data Base Design, Housing User Requirements, Housing Data Structure, Housing Performance Requirements, Performance Attributes

SUMMARY

Objective of this study is to develop a data base (DB) to be used by architectural as well as construction firms while they are making decisions in the process of design and production phases of housing.

The stored data relate to the performance attributes of housing spaces. The attributes lead to performance requirements depending on legal documents from all over the world. This DB system consists of data files, application programs, user programs, guides and glossary. Data files of DB consist of three sequential file families. The first file is related to bibliographies of publications. The second file is prepared to contain building level, building subsystems and the number of persons in the dwelling. The third group of 15 files is allocated to the user requirements with reference to performance attributes.

The first group of program family contains application programs designed for various purposes such as editing, merging, sorting, multiplying and searching. The application programs are sometimes used only for one purpose but in general two or three of them are combined together to simplify user entries. The second group of program family is designed for users, as an aid for their requirements from the DB. There is also an alphabetical glossary of the DB and a manual prepared for users.