

From CAD to IT

- changeover of working method

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This article presents a number of factors indicating the change-over from today's drawing-oriented to model-oriented CAD and a broader use of information technology, IT, in an IT-infrastructure in the construction sector.

IN THE SHADOW OF THE FINANCIAL CRISIS which is now devastating parts of the Swedish construction and consulting companies, there is every reason to examine critically how the companies acquire fresh know-how and new techniques to develop their working methods.

Sooner or later the companies must, among other things, evaluate the results of the investments of recent years in computer aids of various kinds and what future developments are needed. Have these investments resulted in the increased capacity and quality improvement promised? Today, companies in the construction sector as well as in other fields have reason to ask themselves if their computer strategies have been right. For some, the question is even if the computers should be put aside and manual working methods be reintroduced. However, it is at the same time stated that the change-over from a manual way of working to computer-aided methods is a fact, and new architects and engineers use the new tools.

These questions may seem to be internal matters for the respective company, but, in actual fact, the introduction of information technology in construction has raised several questions of common interest to this sector. This is, among other things, illustrated by the joint concentration by the Swedish Council for Building Research (BFR), the Swedish National Board for Industrial and Technical Development (NUTEK) and the Development Fund of the Swedish Construction Industry (SBUF) on a national programme for information technology which has been running for almost a year at special centres at the three institutes of technology in Stockholm, Gothenburg and Lund. A central concept in this concentration is so called product modelling. This has come to engage researchers as well as planners, building contractors and real estate managers.

Let me illustrate briefly some of the questions that may be raised on the possibilities of effecting the change in working methods constituted by

information technology and say something about the strength of the winds of change involved in the new infrastructure for information processing. I will limit myself here to look at these changes from the perspective of the architectural and technical consulting companies.

Introduction of new technology - computer-aided drawing

During the last decade, the CAD technique in the form of computer-aided drawing has been introduced. Today, as much as 80 per cent of the Swedish architectural and technical consulting companies use systems for computer-aided drawing. After a very hesitant beginning, the bulk of these investments were made during the last years of the recent business boom.

The reason why rather simple, but well-functioning 2D CAD systems with visualization possibilities run on powerful personal computers are successfully used in the offices of many architects and technical consultants is that they are regarded as tools among other tools. The CAD system is seen as an electronic pen well adapted in a tested tool-box. With these systems, drawings are reproduced, not the three-dimensional building with its technical specification.

The introduction of computer-aided drawing has been made maintaining the traditional role-casting in the architectural and technical consulting companies as well as in the building process as a whole. Exactly the same reports and documents as those produced before. The results are printed out on drawing film and the copying agencies' messengers deliver copies to the clients. The division of responsibility between different actors is only marginally influenced. The sensitive sketch process is affected very little.

The increase in efficiency so far achieved by computer-aided methods has only applied to certain sectors of the construction process and has by and large only paid for the computer introduction. The information is not being forwarded to be reapplied or used for other duties, for example calculations. Certain positive consequences may be seen in the form of more meticulous, and in

certain cases better coordinated, documents. The greatest importance of today's technology lies in its having paved the way for a future modernization of the construction process.

CAD is leaving the beginners' stage - product modelling

The computer aids of the future (CAD systems) will not have the drawing as its object and model of representation. It will be an information system built on an ingenious and multi-purpose representation of the building. The idea is that the information built up by, among others, the architect in the early stage of the construction process will be reused time and time again during the construction for production planning and follow-up purposes, and its objectives are to be of use during the long administration phase.

The graphical and alpha-numerical representations are interconnected in an object-oriented relational database. From the database, the documents needed on various occasions are projected, for example drawings, descriptions, calculations, quantity specifications. A change of a detail in the database results in a change in the graphical representation. The same detail occurs only once in the model. This presupposes, however, already defined, distinct connections between data, i. e. a product model.

In this way, it is possible to analyze, simulate and visualize. To make a load analysis directly from the product model, to simulate air flows in the building as a whole, to visualize the light processing in a room, schematically or very lifelike, where for example the materials handling can be shown lifelike in a mixture of daylight and artificial light. You wander through the model in real time - i. e. the computer counts so fast that the pictures are produced in a film sequence, whose contents are decided the very same moment by the person who looks at the screen. Another application for this technique is to plan and visualize the work on the building site in advance. For the benefit of production planning and organization of the work with regard to the safety of the building workers.

Great expectations are also attached to the possibilities of making an automatic quantity take-off for cost calculations in the various planning stages.

The intended working method means that the computer systems are interconnected with one another in the offices and between the offices. They connect architects and designers with one another – today we talk about groupware, interactive, decision back-up systems.

Changeover from drawing-oriented CAD to model-oriented CAD

On different levels work is in progress on the preparation of a changeover from drawing-oriented to model-oriented computer aids, and a gradual change of CAD technology is taking place. From today's system based on the computer being used as a drawing tool in a "traditionally" organized planning and design process, to a future system where the building to be is stored in a multi-purpose manner in the computer through so-called product modelling.

It may be mentioned incidentally that at Chalmers we work with an application within the IT project mentioned earlier which we call "Computer-Aided Building Box", the aim of which is to enable good solutions to be saved, retrieved and reused in a rational way.

The product model is a (future) standardized agreement regarding the kind of structures in which the information about a building is to be arranged. Such prestandardization is going on in the USA and in Europe. The halting Swedish steps in this matter require a separate report.

My point here is that product modelling contains another dimension than computer-aided drawing. The manual working method cannot be copied. *We will not make drawings of houses with computers but model the prospective building.* A new approach will be introduced. The company's work methodology in the planning and design process as well as its products in the form of documents will be changed. The same is true of the forms of the company's responsibility and its debit system. The new technology will

thus affect the architectural and technical consulting companies as a whole, but also the companies' relation to the world around them: clients, sub-consultants, building contractors etc.

Maybe, it will therefore be impossible to introduce this technology into the construction sector in spite of the fact that it fits into other fields?

For the architectural and technical consulting companies that want a strong position in the building market of the 90s, it is necessary at least to consider the possibilities of the new technology. To describe its consequences and business opportunities. To examine critically whether the obvious possibilities of the technology can be combined with what the customers will request and are willing to pay for.

What, then, argues in favour of this picture of the future having some degree of credibility?

Ten change factors

1. New forms of procurement

– new demands on documentation

One background factor of this project is the new demands on the work of the architect and designer by the world around them. It is no longer self-evident what documents a firm of architects should produce in a project. New forms of procurement, procurement through negotiations, split contracts and design/build contracts mean that the information in the consultants' documents is to be stratified in a new way and be completed at other points in time in the construction process than before.

This requires planning and design systems which permit quick and reliable editing of information.

2. New role-casting between

the building material industry and the planners

A new distribution of tasks between, for example, the architect and the producer of building material means that, in certain respects, the architect will draw fewer details and, in other respects, will have greater possibilities of working out standard components in detail. The building ma-

material industry wants to sell complete sub-solutions including design but will also, through its computerization, offer the architect the opportunity of working out in detail what were earlier fixed designs. The products of the material industry are illustrated in digital catalogues which are available direct via the planners's CAD computer.

If the architectural company wants to play a leading part for the product determination in future too, it will probably be necessary to communicate with the material producer and interactively describe and evaluate various designs. This will be done via CAD models.

3. Electronic trading

Automatic quantity take off and computer-aided cost calculation make the contractor's work more effective. However, what is known as electronic trading will above all change the traditional work pattern. Invitations for tenders will be drawn up according to international standard, EDI, and purchase and delivery agreements will be made via computer networks. This can be facilitated if there is a digital model, a product model, structured in a way agreed on in advance for the sector, from which quantities and specifications can be obtained. It must, of course, be possible to do this at different stages of the process and with various degrees of exactitude.

4. Catalogues, experience, regulations in open databases

The building industry's rules, in laws, directives and standards, are now beginning to be available via databases. This means that they can be updated more quickly than today.

The products of the construction industry are now being made available for documentation in CAD systems. This also includes information on building supplies in the Swedish Building Center's big database, which is now being modernized, and the vast amounts of information in libraries and experience banks such as Byggdok (documentation compiled by the Swedish Institute for Building Documentation). Lists of, for

example, hazardous materials or approved designs will probably be of great importance with a view to finding good solutions and protecting companies against large claims for damages. Searches can then be made direct from the architect's office.

With the help of so called knowledge systems, an intelligent search is facilitated in these databases. It will gradually be necessary for the architectural and technical consulting companies to have a direct link with these databases.

5. Geographical information systems

Geographical information systems are now being developed at local authorities. In the long run, they will contain basic data maps (terrain models), current detail plans and information on the technical infrastructure: road networks, supply systems etc.

An increasing number of data, also demographic and social, are being given coordinates.

The architectural and technical consulting companies have a direct need for access to this information. Information on completed projects must, however, also be given to the databases of the local authorities.

6. Real estate management

The design, construction and management process may be seen as an information process. The information built up in different stages of the process can be handled financially and be reapplied in the management phase. In my opinion, the design phase should not only result in an enquiry documentation but also provide basic data for drawing up a multi-purpose management document.

In my vision of the future, the outlook on the management of buildings is widened from a purely technical perspective to a strategic one where the information on the possibilities of the building comes to the fore. Therefore, the management document should comprise data for care, running and maintenance as well as information on the building's structure, technical systems, fixtures and flexibility of use. The information

should be accessible and presented in such a way that the present and planned use of the building is easy to understand. The structure of the information should be in agreement with the substance of practical and strategic management work.

The demand on the substance and design of a management document will, therefore, differ strikingly from the traditional building document, which is today accorded a central position in the construction sector's contract and responsibility system.

Today, the idea of a particular management document is often restricted to a somewhat enlarged relational drawing. Strategic management, however, presupposes information which gives an overview of the real estate property. This applies to its location, size, contents and design, technical condition and use as well as its financial position: investments, loans, rents and income etc. One basic demand is that the information is comprehensive at a predetermined level and that it is up-to-date and correct.

What is needed in practical management is a combination of schematic, general information on each single property and detailed, technically precise information on certain components and technical systems in the building. It may, for instance, be a question of general information on letting and necessary reparations, detailed information on locking systems, care of the ventilation equipment and emergency measures in the event of leakages.

In the event of alterations, much of the information available in the original building document is, naturally, needed, but it must be adjusted "as built". It is then a matter of coordinated and highly detailed information.

Every major real estate manager has large archives of drawings with data about existing properties. This information is very rarely suited for immediate use neither in strategic management, nor in decentralized, practical management. The real estate managers will in future have to pay particular attention to the question of how old, extensive drawing archives may be used.

Some of today's management is computer-aided, for example letting. The question is how the administrative data processing can be combined with information based on maps and drawings for the presentation of strategic data suggested above.

It may become an important competitive device for the planners and designers to be able to provide a product model which meets the requirements of real estate management.

7. Consequence description

One result of the new system of responsibility which is now being discussed with a view to its introduction into the construction sector may be fewer governmental building regulations and more court decisions. As a result, it will be important for the companies to document what conditions and quality levels are to be reached in the individual project in order to demonstrate that the company has fulfilled its commitments. Among other things, it is a question of assessing whether the prescribed functional requirements have been met.

As I mentioned in the beginning, so-called product modelling means in principle that a complete model of the future building is stored in the computer. On the basis of this, it is possible, for example, to simulate the outcome of different designs and to carry out advanced, photo-realistic visualization with the aim of making it possible to understand and assess what has not yet been built.

8. Demands for increased quality assurance and increased productivity

Concurrently with the late computerization in the building sector, efforts have also been made to introduce systems for quality assurance. New forms of procurement and increased competition have resulted in the fact that architectural and technical consulting companies have been looking for methods to enhance the efficiency and lately also – as a consequence of the deep financial crisis – the productivity of their work.

However, there are probably few companies which have managed to utilize the full potential

of their computer systems, as the computerization has taken place within the framework of the traditional manual design process. The digitally stored model of the future building has, as mentioned above, remained within the office. The joint rules needed to bring the model to the attention of other participants in the construction process have been lacking. As a result, the possible increase of efficiency has failed in part to materialize.

It has also turned out to be risky to incorporate standardized quality assurance systems in artistic work, and many people question the possibility of producing good architecture when faced with demands for increased productivity. This "overall" uncertainty is, in my opinion, based on the fact that, to a large extent, people are unaware of how their work is in fact organized. It has so far been possible to work wholly traditionally in a drawing office, studio or one's own "den". However, in future this will not be enough. The companies will have to become more professionally organized. Computer aid in various forms will, in my opinion, be required to increase productivity, at the same time as the quality of the products of the companies may be assured in an economical way.

9. Architecture – the relation

between design and the tools for design

At present, there is no computer system suitable for sketching the way we look at this concept today. However, it is not possible, as we have done so far, to computerize the work but avoid the sketch phase. The traditional division of stages is changing, and wishes for, for example, early cost calculations with great accuracy will necessitate sketch modelling of different alternatives.

This means that we have every reason for trying to describe how the new technology influences the core of the architect's work. Probably, there is a strong relation between the tools we use in the very special work of design and the result of this work. It is easy to raise many critical questions as to how the artistic work as part of the building process will be affected. At the same

time, many artists and architects see opportunities for new expressions through the medium of computer techniques.

10. Internationalization

Our way of drawing and describing houses must be open to the demands made on us from an open, international market. Already today, architectural and technical consulting companies cooperate with colleagues abroad. Our respective computer systems must be synchronized. The international standardization work for product modelling is under way at present, and a specific part of this work concerns standardization of product modelling in the construction sector in Europe. Knowledge about this work among practitioners is low in Sweden, and insight into this standardization work and its results may be a competitive device.

New patterns, new forms of cooperation, new needs for know-how

Together, these development trends may be a strong force behind changes affecting the methods we use in the design, construction and management phases in future:

1. We will see a changed design and construction process with a new division of stages and roles between different occupational groups. We will need to describe the new patterns of cooperation appearing right now. Many descriptions of the construction and design process are far too simple today, with its linear courses and schematic, trade-guild stage divisions. This hints at the fact that concept development for the design and construction process is an urgent field of research. It is an urgent research task just to be able to describe the new patterns in step with their formation. The result of such research will help the practitioner to see clearly.

2. The introduction of IT means a change in work methods of a totally different dimension than before. It is the matter of a change of technology with positive and negative consequences. The introduction of IT will not be

successful if we do not form an expoundable conception of what characterizes the creative and construction process (the design process). We must understand why the work is carried out in a certain way. The computerization must be based on a deep knowledge of the professional contents.

3. We will see the growth of a number of professionally run companies. Few have seen the architectural firm as the mould in which the creative architectural work is organized. A superimposing of free creative and personal exploratory work and the systematic, well organized project group work. The introduction of computer systems, quality assurance systems as well as methods for increased productivity have indicated the need for a renewal of design methodology. The actual change of technology will put the company managements to the test and require its own strategy.

4. In order to be competitive in the future, it will be important to be able to reapply and perfect good, reused solutions, to have access to reference solutions. It will be important for the companies to know how to use general know-how and to be able to put knowledge formulated by others into practice. This requires a systematic way of working and knowledge of how to utilize the database approach – in the individual

project, in the company's own experience banks and in general, joint databases.

5. Major investments in equipment will be necessary, but above all in the form of access to competence. This will contribute to strengthening the change of company structure triggered off by the financial crisis.

Research areas

1. Description of the ongoing change of the planning, construction and management process which will facilitate understanding of the changed conditions.
2. Continued research in design theory to give us concepts for discussing these changes and the consequences for the professional content.
3. Continued and refined classification of "building" components structured in such a way that they are useful in the planning as well as in the construction and management stages.
4. Definition of joint product models.
5. Transfer of standards to computer media so that the latter will be easily accessible.
6. Data communication, conversion between various CAD systems, systems for the filing and protection of building models.
7. Further development of the interfaces between the computer and the user with a view to increasing accessibility.

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