Integrated computer-aided building design; research, development and standardization in the Nordic countries

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ABSTRACT

In all of the Nordic countries the topic of integrated computer-aided building design and construction has received a lot of attention. This paper describes the efforts that have been made in Denmark, Finland, Norway and Sweden, to pave the way for an integration of data processing in the construction industry. It is based on a survey made by the building research establishments of the four countries, with financial support from the Nordic Council of Ministers. The design process and the effects the introduction of CAD systems will have on the process are currently being studied in a growing number of research projects. Public construction projects have been selected as "guinea pigs" for trial use of integrated computer-aided design and the experiences are recorded by impartial research teams. Standardization work is under way in all of the countries concerning exchange formats for digital building information, the refinement of classification systems and the revision of draughting symbols.

La conception assistée par ordinateur integreé des bâtiments; recherche, developpement et standardization dans les pays Nordiques

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MOTS-CLÉS

CAO, Processus de Conception, Integration, Recherche empirique, Standardization

ABSTRAIT

Dans tous les pays Nordiques le sujet de la conception assistée par ordinateur integrée des bâtiments a recu beaucoup d'attention. Ce presentation decrive les efforts qui ont été faits en Danemark, Finlande, Norwége et Suède pour aider l'integration de l'informatique dans la construction. Il se base sur une étude fait par les institutions de recherche en construction des quatre pays, avec financement du Conseil Nordique des Ministres. Le processus de conception et les effets de l'introduction des systemès CAO sur ce processus sont actuellement étudies dans un nombre croissants des projets de recherche.

Des projets publics de construction ont été choisis pour une utilisation experimentale de la CAO integrée. L'experiments sont suivis par des groupes neutres des chercheurs. La standardization progresse aussi dans tous les pays dans les domaines de l'échange des données digitales de construction, l'élaboration des systèmes de classification et la revision des symboles des dessins.

1. Introduction

In most industrialized countries construction firms and design practices are acquiring computers and software at a rapid pace. There is a growing awareness that a certain degree of industry-wide cooperation is needed in order to solve a number of key problems in the utilization of computers in construction.

In all the Nordic countries government authorities, construction industry trade associations, universities and research institutes, as well as construction information services have recently become actively involved in research, development of methods, software and databases, refinement of standards and classification systems, and dissemination of information concerning computers in construction. Organizations devoted to coordinating such activities have been created on a national basis.

A further level of cooperation is the international level, as represented by the Nordic countries or the European community. In order to define a common policy in these questions the Nordic Council of Ministers commissioned the report on which this paper is based. As a result of the report a draft co-operation program for the years 1986-88 has been presented in February 1986 to the Nordic Council of Ministers. In the following some interesting on-going or recently finished Nordic projects are presented.

2. Evaluation of CAD in use

It has become increasingly clear that the main difficulty in implementing computer systems in the construction industry is that the implementation necessitates development of the design and production process itself. The only way to find answers to such questions is through systematic observation during design projects where CAD-systems are used.

2.1 The Swedish Bollnäs project - a forerunner

The Swedish Board of Public Buildings commissioned the design of an office building in Bollnäs from a team of design firms using the same CAD-system (MEDUSA) and collected the experiences in a systematic way. The study was carried out by a team of independent researchers.

Some conclusions drawn from this project were:

- A standard for the use of layers in integrated projects would be useful.
- One relatively simple way of utilizing CAD systems for detecting overlapping structures and installations is to use the layering facility to produce simplified drawings containing only the relevant information, which in turn makes manual checking by looking at the drawings more simple.
- The routines for defining authorized drawings, originals and revisions should be further developed as a part of the system software.
- It is not advisable to use a CAD-system (of the traditional turnkey type) for the early, creative phases of design.

Overall it was found that the use of CAD can provide a means for better communication and coordination in the design process. The Bollnäs project has been followed up by a study concerning the benefits and disadvantages of CAD-produced documents in the construction process.

2.2 A Finnish Pilot Project

Inspired by the Bollnäs study the Finnish Board of Public Buildings together with the Technical Research Centre of Finland are carrying out a similar study on the use of CAD in the design of a new laboratory for the Technical Research Centre. The framework of the project differs somewhat from the Bollnäs project since two different CAD-system (MEDUSA and DOGS) are used. Data will be transferred between the two databases at regular intervals using conversion software made specifically for these systems. One focus of the study is thus on how integration will succeed in a project with more than one CAD-system. The working patterns of the designers at the workstations will also be systematically followed.

2.3 Two Danish demonstration projects

Two studies of the use of CAD in real design projects have been carried out in Denmark. An extension to a laboratory for the Danish Post and Telegraph Board has been designed using the large turnkey system (INTERGRAPH) of a large multidisciplinary design practice. The design phase was completed by the end of 1985. The emphasis was more on demonstrating the use of CAD in a real project than on actually studying the effects thoroughly.

The second Danish demonstration project focused on the use of cheap micro-based systems in building design. Small and middle-sized Danish consultants already use a large variety of micro-based programs for draughting, structural calculations, dimensioning of HVAC systems etc. The idea was to study how these tools could be used in real design projects, and how the exchange of information between the participating designers should be organized in order to enhance the efficiency of computer use.

3. Data exchange and draughting standards

3.1 The overall situation

The key standardization areas related to computers in construction fall into two distinct groups.

The first group consists of areas which are relevant to software integration in construction, but which the construction industry itself cannot influence. Examples of such official or de facto standards are the ISO open system architecture, MS-DOS, GKS and IGES.

The second group consists of standardization areas which the construction industry itself controls, such as classification systems. The growing use of CAD has also created pressure for minor revisions of draughting standards.

3.2 Exchange of building specifications

The Norwegian Council for Building Standardization has issued a standard (N 3459) for the exchange of alphanumerical building documents. The standard concerns documents such as building specifications, which have been produced on micros using general purpose wordprocessing software. The aim is to make it possible to exchange such documents digitally between different participants in a project. In the standard five types of data records are defined. Each record consists of 80 alphanumerical ASCII characters. In each record certain fields are reserved for codes defining what information is contained in the record. Most of the fields are left undefined in the standard itself but should be defined by the supplier of the information.

The Norwegian contractors' organization has also issued a standard proposal, based on the same principles, for the exchange of activity networks. These are typically used in project planning and management software.

3.3 Exchange of data between CAD-systems

The fact that IGES standard in its present state hasn't proved adequate for the exchange of building data between different CAD-systems has lead to the development of partial solutions to the problem, in the form of links between specific CAD-systems. As market demand for such conversions grows, "bilateral" software will undoubtedly be developed and sold by system vendors. Attempts are, however, also made to develop conversion formats that compete with IGES. Development projects aiming at the construction industry are at present under way in Denmark, Finland and Sweden.

In the proposed Finnish format , which primarily has been developed for the transmission of building part drawings from structural designers to component factories, the overriding concern has been to minimize the time needed for transmission

of data using modems and telephone lines. One major criticism of the IGES standard is that it tends to result in code many times as long as the original data.Some of the characteristics of the proposed exchange format are:

- Sequential data files in ASCII format are used
- All numbers are coded using the visible ASCII characters as integers in a 94-based system. Some can also be stored in the form I*10**J where I and J are 94-based integers.
- The numbers are of variable length.
- The graphical entities defined by the GKS standard are used in the standard.
- The file consists of entities of variable length.
- A set of subroutines written in the FORTRAN-77 binding to GKS write and read the conversion format file.
- Conversion programs for different CAD-systems will be written using these subroutines by software vendors.

3.4 Draughting Standards

In Sweden the Building Standardization Institute has carried out a study which looked at the need for revisions to construction drafting standards. It was found that very few conflicts existed between the demands of the standards and the capabilities of current CAD-system. Present vector based CAD-programs have problems coping with certain symbols or use disproportionate amounts of CPU-time to create these. New types of output devices should solve these problems.

CAD offers a range of new possibilities for more flexible and user-friendly documentation. The proposals for new areas for standardization, which are put forward in the report, seem quite interesting.

- layout and size of symbols and text in different scales
- degree of detail in different scales
- CAD documents for different phases in the construction process
- use of layers
- use of colors
- structure and positions of symbols
- structure of non-graphic attribute data
- three-dimensional standard symbols

4. Computers in the construction process

4.1 General situation

Among the most interesting areas for R & D related to information technology in construction are:

- production planning and management systems
- robotics on site
- expert systems

- CAD/CAM integration
- automation in prefabrication

4.2 Production planning and management systems

From the point of view of the larger contractors production planning and management is one of the most important uses of computers. This fact has clearly been recognised by the Federation of Swedish Contractors which has initiated a large development project stretching over a number of years. The basic idea is to do co-operative development and standardization work in parallel with in house development work in the firms involved. One of the main tasks of the Swedish project is to further develop present classification systems in order to meet the new demands posed by computerization.

4.3 Robotics, expert systems

In a project partly financed by the Federation of Construction Workers the effects of computerization on the work of the construction worker will be studied. The study consists of two parallel tasks, a theoretical study and pilot studies in connection with four real construction projects.

In a prestudy published in 1983 some impacts of computerization are already outlined. The workers' needs for a reasonable work space in crammed parts of the building could already be checked during the design phase. The use of CAD systems, which include a layering facility, should make it easier to evaluate a design from the construction workers point of view. (This could be one among several potential application areas for expert systems in construction). Product data bases could also easily contain information about health risks associated with chemicals etc. This information could be transferred to the building specifications.

The accident rate of construction work is among the highest of all branches of industry. Work on site is also often done in a tough climate and in difficult working positions. Sometimes workers have to handle dangerous chemicals. Robots could be applied to dangerous, repetitive and cumbersome work tasks on site. Robotics in construction work has so far been very little studied in the Nordic countries. Projects in this field are, however, starting at least in Norway and Finland.

4.6 CAD/CAM interfaces

The computer-aided draughting of building plans isn't only an end in itself. The cost savings which can be achieved in the design process are much smaller than the benefits which can be achieved through the use of the building data base as input information to other applications. The most important one's are:

- contractor's quantity take off and cost estimation
- production planning and management
- computer-aided manufacturing of prefabricated parts
- construction robot systems
- maintenance and facilities management systems.

In a recently finished Swedish project the aim was to study how drawings for different uses in the construction process should be structured, using the layering facility of CAD systems. One aim of the project was also to develop new drawing types which would be better suited to the needs of the end users.

The use of computer produced drawings as input data for the production planning and eventually computer aided manufacturing (CAM) systems of the prefabrication industry is studied in Finland and Denmark. The key issue in this field is to define a standardized data exchange format between the structural design office and the factory.

5. Conclusions

In the long run the main problems in implementing computers in construction are organization and training. One of the observations that were made during this study is that organizations concerned with furthering the use of computers in construction in the Nordic countries have grasped this important fact.

There seems to be a widespread consensus in all the Nordic countries as to what ought to be the target for cooperative efforts and the reasons behind this. Providing an infrastructure of classification systems and information exchange routines, which paves the way for the integration of computer applications of the different participants in the construction process, must necessarily be a high priority. Such integration will lead to increased productivity in both the design and construction process and will enable Nordic firms to better compete for projects in third countries.

The second big priority is better quality in all phases of the process: better presentation of design alternatives to clients, better evaluation of cost consequences of design decisions, less faults in plans, better working conditions for construction workers, better end products.

REFERENCES:

Björk, Bo-Christer:
Computers in Construction - Research, Development and Standardization Work in the Nordic Countries 1985, Nordic Building Research Cooperation Group, Working group for information technology (NBS-Data), published by Technical Research Centre of Finland, Espoo, Finland, February 1986, 80 p.