Chapter 19

CAD in Polish building

A. Kociolek

There is little CAAD in Polish architectural design offices, and only recently have practising architects discovered the computer. On the other hand, CAAD has been used for some time in research and development based at universities or in large design organizations.

This chapter gives a broad picture of the computerization of building design in Poland, a complex process which concerns planning and financing, hardware, software, CAD practice, standardization, training, education, etc. Here architectural applications are treated on an equal basis, together with other applications representing design disciplines involved in design, such as structural and mechanical engineering.

The underlying philosophy of this chapter is a belief that proper and well-balanced computerization of design in building which leaves creative work to human beings should result in better design and eventually in improvements in the built environment. Therefore integration of the design process in building seems more important for design practice than attempts to replace an architect by a computer, although the intellectual attraction of this problem is recognized.

Computerization of the design process in Polish building has been carried out on various levels:

(1) planning and financing,
(2) hardware,
(3) software,
(4) CAD practice,
(5) standardization
(6) training of designers,
(7) education of future designers,
(8) user groups.

All these aspects of computerization have been supported by research and development activities. Computerization of design is a process. One cannot computerize design overnight, although here and there, mainly among design managers, one can come across a view that it is sufficient to install a computer in a design office to have the office computerized next day.

Computerization of design in Polish building began some twenty-five years ago, and its beginnings go back to the late 1950s. People then were fascinating by the new tools called 'electronic brains'. To engineers used to a slide rule the speed of operation seemed incredible. At that time computers were used in design mainly by hobbyists. In time, more people working in design gained interest in these amazing machines.

In 1963 the Polish Union of Design Offices set up a computing centre, a software house in fact, called Etoprojekt. It was the beginning of the planned computerization of building design. At about the same time the first Polish computers were produced, called ZAM, with external memory on magnetic drums and with Polish software. A high-level language, SAKO, was then developed for these computers and so were compilers for that language. A few ZAM machines are still in operation. Etoprojekt developed applications software for structural mechanics, water-supply networks, central-heating networks, electrical installations etc., which was intended for use by design engineers working in design offices. Perhaps it was more important that the centre trained many specialists in design computerization who joined design offices for industrial building in 1967. They introduced applications software developed by Etoprojekt to their design organizations, provided user support and developed applications by themselves. Towards the end of the 1960s computerization of the building process, which had previously been carried out by specialized institutions, was integrated by Centrum ETOB, a computing centre for the construction industry set up in 1969. At the same time the Ministry of Building and Building Materials Industry set up a research and development project called 'Improvements in Methods and Techniques in Design', which was coordinated by Centrum ETOB. This organization coordinated computerization of the whole building process. The arrangement did not last long because in 1975 responsibility for computerization of design was placed with BISTYP, a research and design establishment for industrial building, while computerization of management activities in the building process was left with Centrum ETOB.

The beginnings of the 1980s brought changes in the Polish economy, which also applied to computerization of the building process. From the organizational point of view, computerization reverted to the early stage before 1963. However, as far as computer equipment, designers' knowledge of CAD and the number of CAD specialists was concerned it was a totally different level of development compared with that early stage.

Now, in the context of a changed economic situation, control of design computerization is reviving, but in a different form. At least three centres of control are being set up, separate from the housing cooperative and industrial and general building sectors.

The period from the late 1950s up to the present can be divided into the following stages:

Late 1950s-1963	Uncontrolled computerization of design.
1963-1969	Planned computerization separate from design and management functions.
1969-1975	Integration of both spheres in Centrum ETOB.
1975-1982	Both spheres controlled separately (BISTYP for design, Centrum ETOB for management functions).
1982-1984	Uncoordinated computerization of the building process.
1984-	Planning in computerization of design is reviving.

Between 1963 and the early 1970s the most widely used computer in design was a Polish computer, ODRA 1204, programmed in Algol 1204, a dialect of Algol 60. It was a reliable computer with a good systems software. The library of applications for this machine pertaining to building design is very large, and the computer is still in use in some places. In the 1970s new development in the Polish computer industry took place which resulted in the production of a new family of ODRA 1300 mainframes and MERA 400 minicomputers, for which peripherals were produced mostly in Poland. Apart from this, a large number of programmable calculators (like Cornpucorp) and minicomputers (Wang 2200) were imported for building design offices. These machines have been serving design very well. From them there have been developed large libraries of applications for building design which are still in use. Algol has been replaced by Fortran and Basic.

In 1980 building design offices had the following computers (Robakiewicz, 1981):

Mainframes	
RIAD 32 and 10	4
ODRA 1305 and 1325	7
ICL 2902	3
oudated at that time	9
Minicomputers	
MERA 400	22
Wang 2200	46
Data General NOVA 840, 3D, 1200	5
SM3	1
VARIAN	2

Programmable calculators (Compucorp, Hewlett Packard and Polish MERA 300): 152

Five years later the situation has not changed much (Krzyszczuk, 1985). The microcomputer revolution reached Poland after a delay. Nonetheless, various enterprises (state-owned, Polish-foreign and foreign) offer about twenty 8-bit and 16-bit microcomputer systems, most of which are based on an IBM PC standard.

The building design process with an accuracy sufficient for the purpose of this chapter may be represented by the following matrix:

	Design calculations	Word processing	Modelling	Design graphics	Communications
Conceptual design					
Technical design					
Production documentation					

This matrix serves as a basis for a brief description of software used by building design offices in Poland.

Conceptual design is an activity in which the creative component plays a substantial role (design synthesis). In Polish building a community of CAD software developers and building designers, especially architects, holds a common view that conceptual design as a complex and as yet little penetrated mental process should be the domain of a designer, at least for the time being. In Poland, as elsewhere, some attempts have been made to computerize the process of design synthesis with practical applications in mind, but few significant results for design practice have been obtained from these attempts. More attention is paid to aiding conceptual design by means of programs carrying various analyses of an output from a process of synthesis, such as programs of simple perspective or simplified design computations. An example of this kind of computer aid is URBOS, a system based on the premisses that design synthesis is done by a designer whereas analysis is done by a computer. The URBOS system is intended for architects as a site-planning tool. The system enables an architect to set up a computer model of his building site and perform various analyses on the model, e.g. perspective views of a housing estate, shadows of buildings on the ground or on neighbouring buildings, earthworks and so on (Klos and Pawelec, 1985). It seems that results of research on computerized design synthesis in the form of systems entirely replacing an architect in this activity will not find practical applications for a long time to come. The question is, however, whether it is at all necessary to replace a man by a computer in performing creative functions in design.

Technical design is a stage of the building design process in which attention is focused on design and detailing of building elements and subsystems. Applications for this stage usually embrace sequences of several design activities such as design calculations, dimensioning and drafting. They perform an iterative process aimed at finding an optimal solution. Examples of CAD systems for the technical design stage are:

- STOPY - a system for design, dimensioning and drafting of grillage foundations;
- FR - a system for design, dimensioning and drafting of grillage foundations;
- AQUAPOL - a system for fully automatic design of water-supply networks. The system can simulate a network in operation as well as breakdowns in the network.

These systems perform their functions fully automatically, and there are others of this kind in use.

Generation of production documentation, both textual and graphical, is little computerized because design organizations have limited access to computer graphics equipment, plotters and displays. Only a few design offices have their own graphics workstations (Krzyszczuk, 1985), and provide user support not only for their own designers but also for outside institutions.

As working drawings are made mostly under pressure of time, design offices reluctantly commission outside organizations to generate production documentation on their graphics systems. Automatic generation of working drawings is used mainly in system building based on steel or concrete prefabricated components. There are a number of CAD systems in use which provide facilities for automatic drafting of the final design (ASTROFF, PASTOR) or the preliminary design (KORAB). Graphics applications of those systems draw data from geometric files which hold descriptions of the buildings being designed. These systems are multifunctional and integrate a series of design tasks with drafting as one of them. ASTROFF and PASTOR are used in the automatic design of reinforced concrete and steel industrial buildings. The output from them includes: internal forces, stresses, costs, material lists, part and drawing lists, production drawings of building structures and foundations.

ASTROFF was sold to Hungary, and under a new name (MASTROFF) has been used in Budapest since 1981. KORAB is a computer-aided design system for the preliminary design of housing estates. (It is described below, in the section on design modelling.) There are also available stand-alone drafting systems like GRAFOS and PETER, described later. The greatest obstacle to the widespread use of automatic drafting is a lack of graphics workstations in design offices. They are still expensive pieces of CAD equipment. Design computation is the most computerized design activity in Polish building. Computational systems which are in use can be divided into three categories:

(1) stand-alone systems;
(2) subsystems of CAD systems;
(3) systems which can be used both stand-alone or as subsystems.

A library of computational systems covers the following areas:

(1) structural mechanics;
(2) air pollution
(3) environmental analysis;
(4) central-heating networks;
(5) ventilation networks;
(6) lighting;
(7) infrastructure networks (water supply, sewerage, central heating);
(8) earthworks;
(9) costing.

The most-used systems are those which deal with structural calculations, and calculations for central-heating installations and for artificial lighting. The following are examples of computational systems:

- TAPP.MX and STRAINS - systems for analysis of building structures based on the finite element method (stand-alone systems).
- KOR - a system for analysis of walled building structures based on the strip method (can be used stand-alone or as a subsystem of KORAB).
- SORPCJA - a system for computation of penetration of steam through building partitions. The partition is a building element separating two climates, e.g. a roof, a wall, etc.

Apart from computational functions, those systems provide facilities for graphic presentation of the results.

Modelling in design, especially architectural design, is most often identified with drafting. It probably comes from traditional design techniques where a design model of a building develops as a set of drawings and textual descriptions on paper. Computer modelling is not yet in wide use in Polish building, but a number of systems based on the concept of a computer model of a physical object being designed have been developed and used. One of them is KORAB, a system intended for residential prefabricated construction. This is used in the design of housing estates at a preliminary design stage in connection with planning of the production process in a prefabrication plant. The system's application programs operate on common data files of three types: component data files, building geometry data files and technological data files. The last-mentioned files can be viewed as a computer model of a prefabricated plant. The model is used in applications which perform the appraisal of a housing estate with respect to production capacity of such a plant. KORAB provides the following facilities for a design team consisting of an architect, a structural designer and a technologist (Kociolek and Radwanski, 1979):

(1) structural analsysis;
(2) calculation of area factors;
(3) selection and location of structural components (optimal configuration of components);
(4) production of drawings;
(5) production of lists of components;
(6) appraisal of buildings with respect to requirements of a prefabricated plant.

Another example is AQUAPOL (see above), whose numerous applications operate on a database holding a computer model of the network being designed. MOCYTER, yet another system of this kind, is used by architects to generate master plans for industrial projects. Its core is a computer model of a building site.

Systems which integrate applications through a common computer model of an object being designed pose theoretical and practical problems which are reported elsewhere (e.g. see Eastman). Our modest experience with these systems shows that among the most arduous problems encountered in their use are (1) input of large amounts of geometrical data, and (2) management of modifications to the computer model. It seems that integrated CAD systems for building design are in their infancy, despite the fact that much effort has been put into making them operational.

Design graphics tasks are present throughout a whole design process, from conception to working drawings. For the purpose of this chapter let us divide these tasks into two groups, a group of small graphics tasks and a group of large graphics tasks. To the small graphics tasks belong:

(1) sketches to aid design synthesis;
(2) schematic drawings accompanying various engineering calculations;
(3) drawings of architectural details.

Drafting of working drawings is an example of large graphics tasks which, unlike computational tasks, is a day-to-day activity in a design office.

Most of the CAD systems used in design offices have as an integral part of a subsystem for small graphics tasks. Each subsystem is used for graphical checking of input data and presentation of results. Stand-alone small design graphics systems based on microcomputers have only recently appeared. There are two approaches to large graphics tasks in Polish building design. For system building, drafting of working drawings is integrated into other design functions in a CAD system. Examples of this approach are the ASTROFF, PASTOR and KORAB systems (mentioned above). For traditional construction, stand-alone drafting systems have been developed such as GRAFOS and PETER (not released yet). Both systems can also be used for system building. A systems workstation consists of a drum plotter, AU digitizer and storage tube. Computerization of graphics functions lags considerably behind computerization of computational functions because of the small number of graphics workstations installed in design offices; also manual drafting is cheap.

Development of applications software for computer-aided design in building has been concentrated in several large design and research institutions which have had their own CAD centres for a long time. The centres have the following tasks to perform.

(1) production of applications software;
(2) user support;
(3) research and development in CAD.

Apart from the design office centres there are also CAD centres active at faculties of building sciences in technical universities. Those centres perform mainly academic and research functions but also participate in CAD software development on a contractual basis. For instance, the Institute for Roads and Bridges at the Warsaw Technical University developed a system for structural analysis (STRAINS) which is widely used by designers. A designer is first interested in reliable and easy to operate programs which can replace him in performing repeatable, arduous and time-consuming functions. He is less interested in improvements to the design process through the introduction of new design techniques which would change his professional habits. This is why we observe some antagonism and lack of understanding between designers on the one hand and computer-aided building design (CABD) pioneers on the other. The two groups have conflicting aims. The latter aims at radical changes in the design process and claims that it knows how to achieve them. Designers, on the other hand, expect from CABD people solutions to their practical problems, which look too trivial to some CABD specialists. This conflict of interests is fruitful. Both groups meet at the design stage of CABD systems and also during a testing period. The principle of designing CAD software in close cooperation with its future users was introduced in Poland some time ago and has been observed at least by some software developers.

Another problem with computerization of the building process which requires a quick solution is standardization of the information being processed, stored, transformed and communicated in this process. The present practice of information flow in the Polish building process requires substantial human intervention. The language used by participants of the building process has many dialects, requiring numerous conversions which information is communicated between participants. These conversions are a source of many misunderstandings or errors, which come to light on site when modifications are impossible or expensive to implement.

Design organizations can be broadly divided into the following categories with respect to their access to computing resources:

(1) organizations without any computer equipment;
(2) organizations leasing various types of terminals linked through a telephone line to a mainframe (mostly ODRA 1305 or RIAD 32);
(3) organizations with their own minicomputer-based configurations of WANG 2200 or MERA 400;
(4) organizations that are a mixture of (2) and (3).

Organizations in the first category make use of software and computers belonging to outside bodies, not necessarily design offices, and knowledge of CAD among designers in these organizations is rather small. The greatest experience in computers exists in organizations within categories (3) and (4). It is fair to say that there are only a few design offices in Poland with no interest in computers at all. In 1980 about 70 per cent of building design offices had various types of computers (Robakiewicz, 1981).

Minicomputers and mainframes do not require a designer to sit at a terminal and interact with the computer. Although the makers of interactive systems claim that their systems can easily be used by designers without any special preparatory training, in most cases this claim is unjustified, and the user communicates with the system through an operator. Generally speaking, a user interface, especially a software interface, is very imperfect. Therefore designers prefer to communicate with the program through a software operator who knows the program and the computer. This is generally sufficient, as most programs deal with computational tasks which do not require instantaneous responses from the designer at run time.

It has been recognized by the community of CAD software developers and users in Polish building design that poor user interface is a severe obstacle in the computerization of the design process. At the moment three standards are in preparation, concerning:

(1) documentation of CAD programs;
(2) standardization of CAD concepts and terms;
(3) methods for evaluation of CAD software.

These are intended for all CAD users and CAD software developers, not only those from the building design field. CAD in building has its own standards for software development and documentation, worked out some 10 years ago and in use since then, although they are not obligatory. Standardization of I/O operations does not exist yet: programs and systems use their own conventions set up by the programmer. The consequences of this approach for the computerization of design in building are appreciated by CAD software developers and users. A group of CAD researchers at the Technical University of Warsaw has been working on a standard module for an interactive input of data to engineering systems (Winiarski, 1984).

If one analyses an average design process of, say, a building or a housing estate one will see that most design tasks are solved by traditional techniques. Computational tasks are solved by means of electronic calculators, word processing is done on paper or a typewriter, drafting is performed manually. The computer is used mainly to perform larger design tasks which can be characterized as those where the time for finding a suitable program and access to a computer, for data preparation and input, for program execution and for delivery of outputs, is significantly shorter than that required to perform the task manually. When those two time periods are similar, many designers prefer manual techniques. This picture is simplified to some extent because it omits large design offices, which use integrated software, computerizing sequences of design tasks, but, on average, the picture is true.

Contrary to the general view, use of computers in design requires at least a rudimentary knowledge of computers and their use. It does not necessarily imply that designers should have programming skill, although it will not do them any harm if they do have it. It implies, however, that the role of education and training in the computerization of the building process is substantial. Young engineers are educated in computer use at technical universities, while designers belonging to the older generation learn about computers on various courses or postgraduate studies provided by technical univerisities or professional institutions. Although a great effort has been made in training and education in CAD there is still a large proportion of building designers, especially architects, who have virtually no knowledge of computers. It is an important factor hampering computerization of the design process in Polish building. Computerization of design requires informed users, and is a long-term process. Education in CAD of young architects and engineers is the most important factor of any significant progress in this field. Faculties of building sciences provide courses on CAD, and their students have direct access to computers during their study. The community of architects has been more conservative with respect to the use of computers in architectural design, and only recently have faculties of architecture shown some interest in CAD education. The change in their attitude seems to be influenced by the advent of microcomputers.

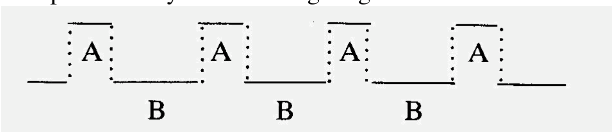
The context for advances in computer-aided design in Polish building is rather specific. At the beginning of the 1980s the continuity of development of CAD was broken, and CAD entered a period of stagnation which lasted for several years, when hardly any computers were installed in design offices. Moreover, some design offices got rid of their computers, losing interest in CAD. Also many CAD people left the profession. At the same time, in other countries, specially in the West, a microcomputer revolution occurred. When CAD in Polish building began to come back to life in 1984 the microcomputer revolution was already banging at the door of building design.

The INFOPRO-85 conference on the use of computers in building design showed a great demand for microcomputers from design offices and the building design community as a whole. It is likely, therefore, that microcomputers will be introduced into design in Polish building in a revolutionary way: in one step. This situation will certainly create many organizational problems.

Microcomputers may fill a gap between the calculator and the mini-computer or mainframe. They have found and will find applications in:

(1) word processing;
(2) performing small computational tasks;
(3) performing small graphical tasks;
(4) small design integration.

The first three applications are fairly obvious, and are reported elsewhere. Let us elaborate here on the fourth, small design integration. Integration of design by a computer is a well-known and attractive proposal. Many integrated CAD systems have been developed, mainly for system building, but only a few found practical applications in design. The practical use of these systems on a large scale faces many difficulties. First, since they are large and complex, they require much effort to learn their facilities and how to operate them, are expensive to use, etc. The tendency to integrate all design tasks on the basis of a common computer model which would develop in parallel with the development of design for, say, a building is an enormous undertaking. An analysis of the communication pattern within a design team during the intensive design process of a large residential building was carried out by the author in 1973 at the Royal College of Art, London; the pattern can be represented by the following diagram:



The intervals marked A represent periods during which the team worked together, while those marked B denote periods when designers were working individually. The time spent on individual work (B) was significantly longer than the time spent on teamwork (A). During teamwork periods (A) designers worked together on a model of the whole building, whereas during B periods they concentrated on designing particular elements of the building. The elements were treated as separate design tasks (subproblems), but in such a way that they integrated into the building. Examples of such elements are: foundations, building structure, external walls, stairwells, floors, elevations, etc. The design of building elements and their integration into a building is an interdisciplinary and timeconsuming task. An integrated approach to building element design should find quick application in practice. The integration can be based on utilization of microcomputers. These integrated microsystems should not have the disadvantages of their larger counterparts. This kind of integration for B-periods may be called 'small design integration', like small computational tasks and small graphical tasks. These concepts do not have distinct boundaries, but they reflect the real design process in building. In future, small integrated systems could interact with large modelling systems, covering the whole object being designed.

A small integrated system for building elements design might have the following functions:

(1) sketching, as with a pencil on a sheet of paper;
(2) drafting, visualization;
(3) management of constraints posed by a design context;
(4) modifications;
(5) archiving;
(6) analyses.

The integration of the activities of all members of a design team by means of a computer will not be common practice in building design for a long time. However, this direction for future computerization seems natural to the majority of the international community of those involved in CAD. The direction is recognized by CAD specialists and also be some designers who have enough spare time, who wish to think about what they are doing as professional people and who want to see the consequences of what is happening in their profession. The majority of building designers, however, seem not to realize how deeply new advances in information technology will change their professional life and their position in the profession.

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