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CHANGES AND ACHIEVEMENTS IN CM RESEARCH AND CM EDUCATION AT THE POZNAŃ UNIVERSITY OF TECHNOLOGY

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1. Introduction

This paper presents some changes and achievements of the Chair of Construction Engineering and Management at the Poznań University of Technology in the fields of education and research between the 6th (Vilnius '97, May) and the 7th (Aachen '99, September) Lithuanian-German-Polish Colloquiums. The first part of the paper describes a specific character and conditions of university training in Poland. Furthermore, some factors influencing academic curriculum planning are discussed. A review of the research is described in the context of writing PhD dissertations.

2. Factors influencing academic curriculum planning and research

There are many factors influencing education and research. The period after our recent meeting in Vilnius (May, 1997) is characteristic: the same tendency has been strengthened. Political and economic transformation which is still under way in Poland has made a number of possibilities available to the Polish people, and laid the foundations of market economy. Also we have seen crucial influence exerted on the ways and directions in education.

An exceptionally fast accommodation of the Polish society to those changes was caused by a beneficial structure of the education system. Table 1 presents a percentage share in education in the selected areas of studies. It is quite clear that Poland had been prepared

Table 1. Students of the Universities according to branches of study [1]

Selected country	Year	Agriculture	Technical sciences	Juridical and social sciences	Humanities	Exact and natural sciences	Medicine
POLAND	1980	27.3	11.0	25.2	5.4	3.4	10.6
	1985	19.4	7.9	21.3	8.5	4.4	13.5
	1991	17.1	5.6	24.9	9.5	4.5	14.5
	1993/4	18.8	5.4	32.1	10.9	4.3	10.2
CANADA	1980	8.7	2.0	28.2	13.3	5.7	7.2
	1991	10.0	1.1	21.2	5.3	4.5	5.2
GERMAN FR	1980	15.0	3.0	26.7	13.8	11.2	15.1
	1990	19.4	2.5	29.1	12.3	12.9	11.0
USSR	1980	45.6	10.2	7.2	*	*	*
	1990	40.9	10.1	6.6	14.5	(97.9)	
UKRAINE	1980	48.2	9.8	8.2 ^a	*	*	6.8
	1991/2	42.1	10.4	7.4 ^a	13.7	*	7.0

^a together with exact and natural sciences

Table 2. A comparison of the ratio of student numbers per 10 000 inhabitants

Country	Year	Ratio	Country	Year	Ratio
Poland	80	166	USA	80	531
	85	122			93
	90	142	Canada	92	709!
	93	195	China	80	17
Lithuania	80	288		93	38
	90	243	Germany	90	258
	92	205		93	232
	93	190	France	81	212
	94	191		92	172
				93	362

for the reform, because the structure of education (Law, Economy) was keeping pace with the trends of the best developed countries. In other countries, educating engineers has been driven to extremes.

It does not signify, though, that the number of university graduates is satisfactory. The numbers of students per ten thousand inhabitants constitutes an objective ratio depicting the situation reasonably well. Selected results are presented in Table 2.

For us, comparing those ratios signifies a requirement of making up for the shortcomings presented above. We can see an increase in the number of students, and opening a number of new colleges (mainly privately run). It has also been agreed that international universities can be established in Poland.

One can look at the change in numbers of students in Poland with a dose of optimism (Fig 1).

The number of privately run universities and colleges has increased from 20 (in 1990) to 144 (in 1998/99). These academic institutions provide mostly courses leading to BSc degree, and the most important areas of study are banking, management, and marketing.

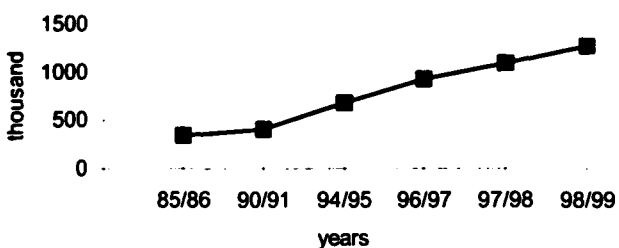


Fig 1. The change in number of students in Poland

In 1986-88, we experienced a deep economic and political crisis. It was reflected by the reluctance among young people to obtain academic qualifications. For example, at the Poznań University of Technology, the number of students was changing according to the following pattern: in 1978 – 8320, in 1986-88 – only 3800-3877 (!), in 1997-98 – 11036-12413, among them 67% studying for MSc degree and 33% for Engineering degree.

At present, we have 2.851 students at the Faculty of Architecture¹, Civil and Environmental Engineering.

Further discussion is illustrated by Fig 2 presenting a number of factors influencing the current situation at Polish universities, and the formation of study programmes. Here is the list of the most popular study courses in Poland:

- Economy,
- Law,
- Management and Marketing.

The most popular faculties at the Poznań University of Technology now:

- Information Technology (Electrical Engineering Faculty).
- Architecture (Architecture, Civil and Environmental Engineering Faculty).
- Management and Marketing (Mechanical Engineering Faculty).

¹ This autumn the branch of study called "Architecture" and the Institute of Architecture and Urban Planning will become a separate faculty.

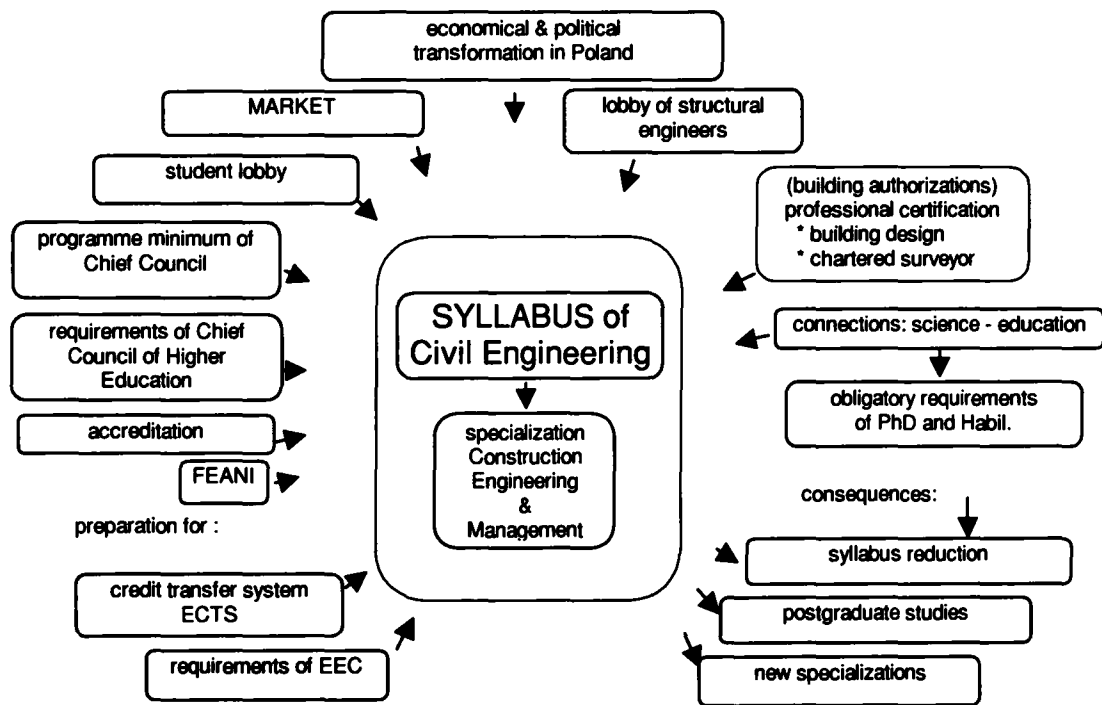


Fig 2. Factors influencing curriculum planning at Poznań University of Technology

- Electronics and Telecommunications (Electrical Engineering Faculty).

The students (and their application forms) exert a certain pressure not only on founding new universities and colleges, but also on the modification of curricula, establishing new courses (for example, MSc courses).

There is a lobby of constructors (to be more precise, construction theory specialists) which often constitutes a voting majority in bodies taking crucial decisions at chairs and faculties. It often exerts a negative influence on the freedom of designing new curricula, especially in management and economics.

Two other factors have to be taken into account when planning curricula:

- the requirements of the Chief Council of Higher Education.
- the Parliamentary Act on Building and Construction Law, including professional qualification certificates.

Two categories of requirements of the Council should be referred to here.

The so-called programme minimum has been laid down. It assumes that the total number of class hours during a study course cannot be less than 2600. The programme minimum includes 1500 hours, and entails

three categories of courses:

A – non-technical courses	300 hours
B – basic courses	450 hours
C – technical courses	750 hours

Eleven courses belong to the group of technical courses, including Construction Engineering and Management and Organisation - 75 hours. Further on, universities may form their curricula depending on their specific character, specialisation, and degree profiles. Obviously, while designing detailed curricula, one should make sure that they correspond to the directions of accreditation and the branch of study set out by the European FEANI Association.

Another important condition set out by the Council is the minimum number of autonomous academic teachers and researchers required for establishing a branch of studies. Therefore, for the MSc courses: at least 8 Full Professors or academics with post-doctoral degrees. For the BSc courses: 4 Full Professors or academics with post-doctoral degrees, and six teachers with PhD. It is usually a major limitation for smaller and younger universities.

For Construction Engineering (CE) graduates, acquiring professional certificates is a basic requirement

before they can start their independent engineering work. Graduates of the CE Faculty can acquire professional certificates in Buildings Design or in Construction Supervision.

The professional certificates, after the candidates have gone through a period of internship and training, and passed their exams, are granted by local administration authorities. Therefore, the curricula (and specialisations in particular) cannot be randomly created. We had seen a failed attempt of establishing a specialisation called "Computer Mechanics".

In order to understand the mechanisms working behind a typical Polish state-owned university, an additional aspect has to be taken into account. There is a requirement stating that research results should filter into teaching. Therefore, in Poland, obtaining a PhD degree is obligatory. Recently a requirement of obtaining a post-doctoral degree has also been introduced. The idea behind it is that such a university would rank higher, but academics are mostly assessed according to their research results and achievements (for example, a number of publications) and, to a much smaller degree, for their didactic achievements.

The implementation of two major projects is currently under way in Poland. The first is the so-called accreditation of departments and faculties and branches of studies. It is aimed at the assessment of teaching level and classification of faculties and departments according to four categories. It is assumed that the Poznań University of Technology will be placed in one of the top categories. Younger universities, without experienced staff, are going to lose.

The other project is the preparation for implementing European Credit Transfer System, the ECTS. It is particularly important for student exchange, but it is also dictated by the requirements of Polish application for the accession to the European Community.

Due to the fact that curricula at the Poznań University of Technology, at the Faculty of Architecture, Civil and Environment Engineering are developed as blocks of courses constituting basic components of programmes for various specialisations, it is going to be relatively easy to implement the credit transfer system. Examples of some blocks are presented in [1].

It is difficult to discuss education without mentioning money and funding. It might be well worth

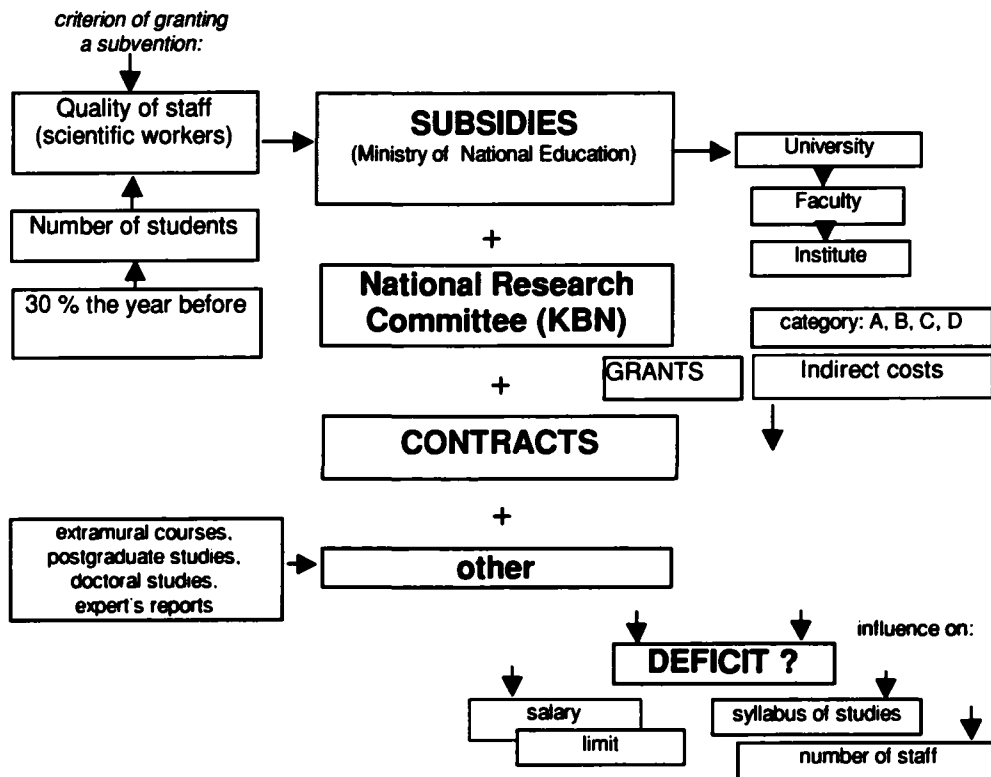


Fig 3. Algorithm of research and education financing at the University

quoting data from two years ago, related to research and implementation spending per capita in various countries: USA – 659 USD, Germany – 459 USD, Poland – 41 USD.

The percentages of the Gross National Product were accordingly 2.72; 2.50; 0.84. It forces the universities to accommodate their academic curricula to the conditions of real life. It does not provide much motivation for implementing difficult reforms.

Governmental Universities in Poland live mainly on the subsidies from the Ministry of Education. Fig 3 presents a way the financial algorithm of the Ministry of Education operates, and the procedures of generating funds by the institutes and chairs of various faculties. This also influences the economic position of faculties, as well as the formation of academic curricula. Namely, a subsidy is envisaged to be a source funding of a branch of study. Consequently, establishing numerous (and new) specialisations is very costly. It is most “beneficial” to teach all seminars and classes within one group of students. It results from the simulations we have made that at the CE faculties (assuming the cost consumption rate to be 2.5) a model structure (in other words, the proportions between various academic activities) is as follows: lectures 1, classes and exercises 0.4, laboratory classes 0.25, project work 0.5.

According to the author, the principles of the Ministry of Education algorithm may stand in a certain contradiction with the system of studying based on credits, in other words, according to the system of taking individual paths in the course of studies.

3. An overview of the situation in Construction Engineering and Management specialisation and post-graduate studies

A course in Construction Engineering (CE) and Management is offered by 19 technical universities in Poland. All those universities work along the lines of a curriculum embracing CE. It can be best seen on the example of a separate specialisation which, depending on a university, has recently been given different names². At the Technical University of Poznań it bears the traditional name of Construction Engineering and

Management (CE&M). At some universities this specialisation is also offered as an extramural course (but on the BSc level).

Extramural students in Poznań can only specialise in structural engineering but it is interesting that the graduates inquire about starting a MSc course namely in the field of CE&M!

The CE&M Chair which is an integral part of the Architecture, Civil and Environment Engineering Faculty runs classes, first of all, in CE&M itself.

In the process of adapting to the Ministry of Education algorithm, we have begun some serious reductions in curricula of the study courses.

At the time, the total number of hours of courses (excluding the length of time devoted to research towards MSc dissertation) was 3.900. The new curriculum embraces 3.315 hours. The percentage share of the three groups of subjects is as follows:

- general subjects 15,84%
- foundation subjects 51,88%
- specialist subjects 32,58%

Despite the reduction in the total amount of hours, the number of specialist hours increased from 960 to 1080.

The CM (construction management) problems are also dealt with at our Faculty within the framework of a 3.5 year studies in Engineering, initiated in 1992, within the TEMPUS JEP3757 programme.

The CE&M Chair co-operated with the Wielkopolska Chamber of Construction which, within the framework of the PHARE Fund, ran an extramural Master course in Construction Management during 1997/98.

We also participate in teaching of MSc course for the engineering graduates.

The CE&M staff fully participates in teaching at the postgraduate (two-semester) course in Valuation of Real Estate (established in 1997)³. The course is run on a fee basis. It is taught by our staff, as well as by the academic staff from other universities (the University of Agriculture and the School of Economics) and by the Ministry lecturers and experts employed in real life construction companies. At present, the third

² For example, at the Warsaw University of Technology: Engineering of Building Processes.

³ A manager: Prof A. Skarzynski [2].

consecutive recruitment is about to end. The numbers of graduates were as follows: 36, 52 and 54. Such courses are taught in many academic centres throughout the country.

We are offering another course of studies, though touching upon similar problems: Real Estate Management and Trading. It will also be a two-semester course. It is aimed at training prospective real estate managers and real estate agents trading in property. The Parliamentary Act obliges all applicants who want to obtain professional licences in "Real Estate Management" and "Real Estate Trading" to join and graduate such an academic course.⁴

4. Research: problems and scope

Research at the Chair of CE&M is carried out (and subsidised) mainly within the frameworks of grants (statutory – DS and University – BW). The mechanisms and influences of this kind of funding were presented during the last Vilnius Colloquium⁵.

Recently, the scope of research has grown, and it is particularly evident in such areas as: macro-organisation, management, law, investment process, problems of restructuring in building and developing companies. The following publications may serve as a good example [3–6].

The following phenomenon is to be observed: those problem areas are the result of a demand from construction practice, nevertheless the Research Councils at the Civil and Construction Engineering Departments do not look at all favourably into the question of presenting PhD dissertations regarding the areas.

Another, quite a new trend in research, closely related to the subject area of the post-graduate courses mentioned above, is the domain of real estate valuation and management. We have already seen the first publications [7–9].

Traditionally, the strongest trend in research is modelling and organisation of construction processes, including the application of computers and artificial intelligence. The survey of all those problems, a synthesis

of the research, and guidelines – also for prospective PhD students – have been presented in a monograph publication entitled "*Modelling of construction processes. A managerial approach*" [10].⁶

Dissertations

Two PhD dissertations have recently been presented at the Chair of CE&M. The abstracts and some characteristic elements are given below.

a) *Methodological aspects of multicriteria decision aid in civil and construction engineering.*⁷

This dissertation is a discussion of some chosen issues and theoretical basis included in the methodological and cognitive part of the research, as well as a presentation of a system of ideas related to the methodology of multicriteria decision aid. A review of multicriteria decision aid methods has been carried out, and the author's own classification of this group of methods has been offered. The examples to date of usage of those methods have also been quoted, relating both to Polish and foreign civil and construction engineering. The concept of multicriteria decision aid has been accepted as a method of solving the selected decision-making problems, as well as the appropriate calculation and computation methods have been selected and duly justified.

Three multicriteria decision problems have been presented and discussed in the research section. The problems pertained to selecting an appropriate order and making a final assessment for a number of options regarding types of floors between storeys multi-layer external main walls in family type housing, and electrostatic flooring in an industrial building. Tests have been performed, related to the assessment of acceptance of multicriteria decision aid as a method for solving the selected problems. A sensitivity range has been defined for the selected methods, and such an analysis for a chosen method has been performed – the ELECTRE III method. A procedure has been proposed to

⁴ This course is organised by Dr D. Pawlicki.

⁵ The allocation of funds for the following year depends, among other factors, on the number of publications in the previous year.

⁶ Prof O. Kapliński's book was awarded a special award in the Building and Construction Department 1998 competition at the Ministry of Administration and the Interior.

⁷ The dissertation was written by Dr T. Thiel [11–12]. It was submitted in 1997. In 1998 the dissertation was granted an award in the Building and Construction Department competition at the Ministry of Administration and the Interior.

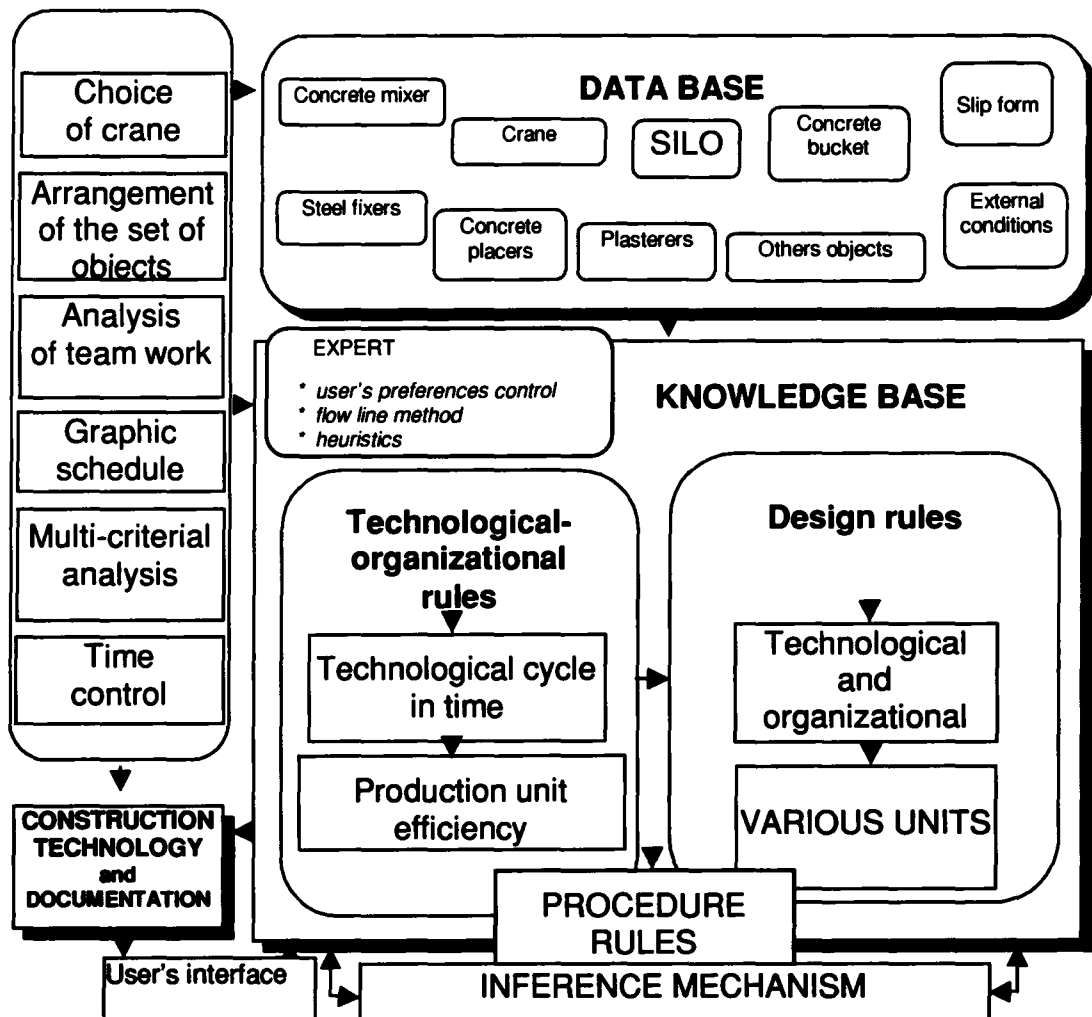


Fig 4. A general architecture of the expert system for construction design of monolithic silos

ensure the appropriate development of the process of assisting decision-making, and this procedure has been used to solve the selected decision-making problems.

b) Rule-based knowledge in the system supporting the design for building grain silos erected by the slip method.^{}*

The dissertation presents an expert system controlled by user's references, supporting the design for building grain silos erected by the slip method. The system is used in monolithic technologies (c.f. [13-17]).

The problem consists in such an arrangement of resources that will enable engineers to erect silo walls at a determined rate. The task takes into account the

following factors: concrete casting time, external conditions, the dynamic character of the construction process (the structure grows with time). The objects, in this case a slip form, silo batteries, cranes, concrete mixers and teams of workers, form a complex system. The purpose of the expert system is to determine the set of objects that may provide the optimum value with respect to many criteria, and therefore a multicriterial analysis is called upon.

A general architecture of the expert system in question is presented in Fig 4. Within the expert system, we may distinguish the following units: database, knowledge base, inference engine, a user interface. A rule of knowledge representation has been chosen. Due to the specific character of the domain, two kinds of rules are now distinguished: microrules, which describe

^{*} The dissertation was written by Dr M. Hajdasz. It was submitted in December 1999. The dissertation has been granted a special nomination by the Department Council.

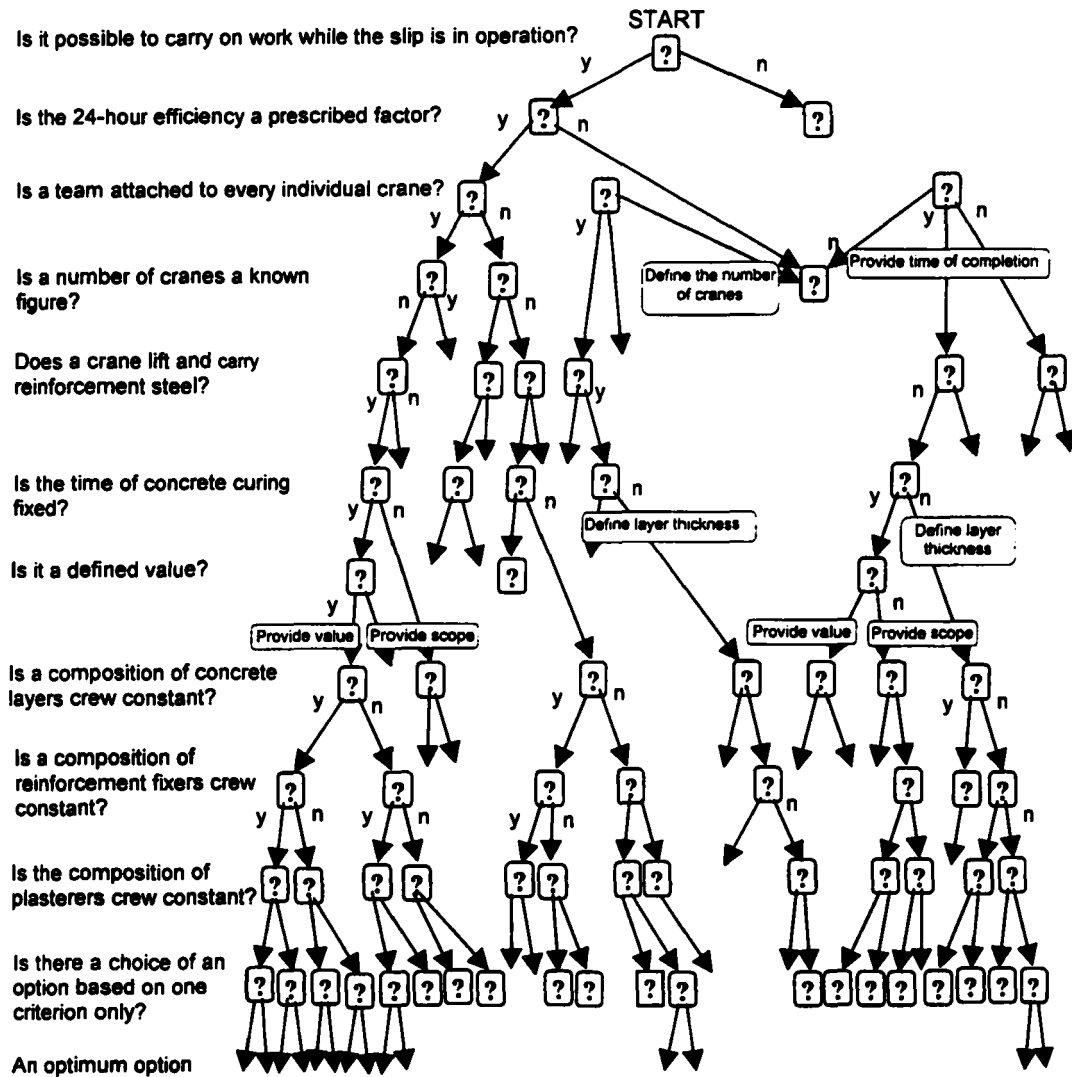


Fig 5. State graph (according to [12])

the technological-organisational processes, and macro-rules that control the design process.

The system is assembled from numerous units. They are integrally involved in the system. Some of these units can be used separately, eg the procedure of accepting a crane, the program analysing the organisation of work teams, the unit arranging the set of objects, the programme preparing graphic schedules, the unit performing the multicriterial analysis.

An interesting unit labelled "choosing the strategies" is presented below (according to [15]). The expert's reasoning was followed in the course of designing the system at hand. The structure of the decision tree refers to the experts' heuristic knowledge, but com-

mon design rules are also included. The state graph reflects the logical structure of the computer system and comprises a wide spectrum of problems of various degrees of detail: from the building strategy of the whole construction to such details as the organisation of the activity of workers' teams. There are many strategies at our disposal. A specific strategy is chosen following the user's preferences which are passed to the system in a dialogue session. A special mechanism was designed to search over the state space.

An example of the range of problems receiving attention is shown in Fig 5. Upper levels of the graph deal with so-called principal strategies in the erecting a construction. These strategies are, for example,

keeping to the determined time of completion of various stages, maximum efficiency in utilising production resources, work kept within a constant daily rhythm. On next level of the decision tree there are set questions concerning the concrete curing time (and it influences the height of a single concrete layer). Next questions concern the teams of workers (are their number and the way they are organised in time or not?). Finally, on the lowest level, a multicriterial analysis is performed, and the optimum variant is found. The building process dynamics is inherently dealt with by the system. The system looks into objectives, resources, regarding both the technology and organisation of the work.

Other research

Presently, other research goes on looking into the issues of modelling economic phenomena and managing databases, with a strong stress on utilising computer sciences. Two subjects related to this research are discussed below.

The first subject is focused on developing and implementing the knowledge related to multidimensional analysis of information stored in new generation databases, all within the area of construction engineering, utilising some elements of optimisation and artificial intelligence. The research is aimed at arriving at a multidimensional, multimedial consultation system used in the so-called on-going investment and building process. It may be practically applied in managing the maintenance of road networks in urban areas.⁹

The second subject is closely linked with the problems of management in engineering and construction projects. The issue of cash receipts and expenditure, and their interrelations, have been particularly well highlighted. Looking from such a point of view, the way cash receipts and capital expenditure is distributed, has become a vital criterion of correctness of the itinerary (and, in consequently, a true measure of good management in a project and in a company). If we look at the problem from the analytical aspect, it is obvious that the stress is mainly laid on specialist software used in managing businesses and companies (time-tabling and

⁹ This research will be concluded with a PhD dissertation to be submitted by A. Fojud (MSc, Civ. Eng.) [18–20]. Recent publications in the subject area are: [9],[10] and [13].

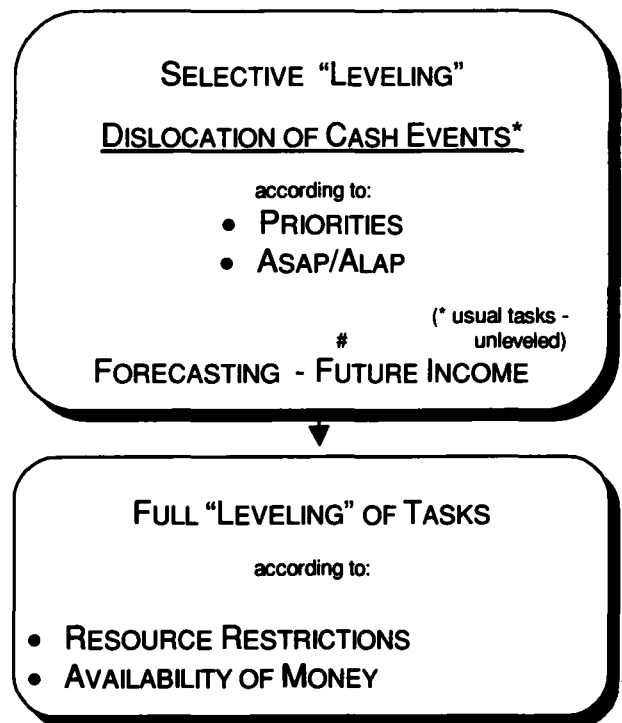


Fig 6. Idea of capital expenditure and receipts analysis in CM

designing itineraries), and a calculation spreadsheet (being the tool which widens the data analysis spectrum). The idea reflecting full analysis of cash receipts and expenses within the computer software is presented in Fig 6. Three main aspects of accounting for funds are pointed at in the research:

- periodical accounting,
- accounting and summing up upon conclusion of construction work,
- accounting in the case of known dates of payments and amounts. This aspect of accounting is a novelty in the research.¹⁰

It is well worth noting that this type of research has also been transferred into the realm of the MSc degree.

We should note that part of the research work is related to international collaboration, for example with France [21], Ukraine¹¹, Denmark¹² and first of all with

¹⁰ Research in the subject area is carried out by Mr. T. Wiar (MSc, Civ.Eng.) [22].

¹¹ Dolotov A. and Sadovskij V. Integrated information support system for design & realization in housing construction // MKIL, No 3, 1997, p. 79-87.

¹² Anderson T. and Gaarlev A. Priorities in construction IT research // MKIL, No 4, 1999, p. 35-45.

our colleagues from Lithuania. We have recently seen one joint publication [23], and a number of publications have come out thanks to our colleagues from Vilnius [7], [9] [14], [24] and [25]. What highlighted the Poznań academic circuit was sending a personal invitation to Prof O. Kapliński to participate in the International Seminar on Construction Management, an event limited by the presence of guests from New Zealand, Canada, the USA, the UK, and Denmark (c.f. [1]).

5. Conclusion and final remarks

Recent economic changes and the fact that a different kind of market, catering for different economic needs has emerged, resulted in a different outlook on the issue of management in technical universities. If, in the past, subjects related to management were tackled in this way or another, they were limited to the organisation of processes on the building site, while company management issues were taught at the Schools of Economics. Nowadays, these questions are coming up at our university, but it is still not possible to write a "pure" PhD thesis on CM (construction management). Such dissertations written here are expected to have a technological bias.

One should express satisfaction of the reinstatement of such courses as Laws of Economy, Construction Laws, Safety and Security Regulations. Following a request of the students, we have recently introduced a course, within the block of optional courses, on capital markets.

According to the author, in the long range, such issues as:

- Robotics (and first of all organisation of construction processes carried out by means of robots).
- Expert Systems (ways of making use of and ways of gathering data for databases and knowledge bases) should be introduced into the academic curricula on the CE.

Obviously, the scope and duration of classes devoted to "traditional" issues, such as feasibility studies, tender procedures, contracts, should be made much wider.

All manners of courses related to property valuation have recently become very popular in Poland. These problems of "Ownership Restructuring and Residen-

tial Resources Management" should constitute a new and separate course in the curriculum.

According to the author, the post-graduate course on "Estimation of Real Estate", mentioned above, should be made into a new specialisation called "Real Estate Management". It does not need to be a five-year course but a 3.5 year course crowned with an engineer BSc degree. This is how a specialisation counterpart of such areas of study in the UK as: Estate Management, Quality Surveying, Building Surveying, can be established.

In the context of the above-mentioned suggestions, the previous, traditional specialisation in the CE&M should embrace two profiles of final projects and diplomas:

- Building Rehabilitation,
- Construction Management and Economics.

Making management less centralised and local authorities stronger has resulted, according to the author, in a need of establishing a new professional specialisation. It would be called "Communal Engineering", and such a specialist would be a mayor's assistant, proficient in two areas:

- management (including CM),
- technical skills, such as environment protection, local transport, waste processing, and so on.

Assessing the research carried out directly at the Chair of CE&M, it should be said that widening the spectrum of research, ie adding such issues as economics of building and construction, construction law, organisation and management in the investment process, is something quite positive. There is no doubt that we ought to contribute much more in order to balance this problem area (and render it acceptable) so that it may be equal in weight to the traditional scope of promotion work carried out at academic institutions where Construction and Civil Engineering is taught.

Judging by the assessment to date, the academic standard of PhD dissertations on modelling and implementation of computer sciences presented at the Chair of CE&M is very high.

The form of supporting research by the Committee for Scientific Research (KBN), indeed, deserves praise. Too little research work, though (in spite of its low cost), is directly commissioned by the industrial sector.

Acknowledgements

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Santrauka

Pateikta statybos valdymo studijų ir mokslinių tyrimų problemų, esamos padėties ir pokyčių tendencijų apžvalga. Aprašytos tipinės programos ir veiksmų grandis (finansavimas, studijų programos ir mokslinis darbas) Lenkijoje. Taip pat pateikti tam tikri statybos technologijos ir valdymo specializacijų aspektai. Naujos tendencijos matomos ir Poznanės technologijos universiteto Statybos technologijos ir valdymo katedros nekilnojamojo turto vertinimo ir valdymo magistrantūros studijose. Doktorantūros studijas galima tęsti studijuojant statybos procesų modeliavimą, kuris yra glaudžiai susijęs su duomenų bazių sudarymu ir tam tikrų dirbtinio intelekto elementų panaudojimu.

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