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A Tempus JEP Devoted to CAD: A Successful Challenge*

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The growing importance of computer-aided design in Western European universities during the last ten years suggested the introduction of a JEP proposal devoted to computer-aided design of structures. At the beginning of 1991, CEC gave the project its support under contract number 0438. This presentation outlines the project's aims, types of activities, the hardware and software support material needed and its exchange aspect. Following is an overview of the results obtained after 16 months of experimentation as well as plans for the future.

BIRTH OF A JEP

THE IDEA of computer-aided instruction in the field of mechanics of structures at the Polytechnic Faculty of Mons led to the development of lectures focusing on the finite-element methods (FEM) within the architectural and mechanical engineering curriculum. In the context of the lectures, students were first given simple, rather theoretical exercises aimed primarily at the understanding of the method. For instance, one exercise involved the preparation of a program for calculating the stiffness matrix of a given FE. Students' contact with practical software was limited: this could only be done through the intervention of a skilled user of mainframe computers. This preceding approach has been termed 'theory to software' and described more precisely in [1] and [2]. Such an approach did not, however, motivate students. Later, the development known by PC and commercial programs based on FEM with extensive graphical possibilities allowed for a new opening including:

- the creation of PC rooms made available to students;
- our faculty main services' choice of a unique and easy-to-use computer program in support of exercises and practical applications in mechanics (structural analysis, heat transfer, vibration);
- the introduction of the CAD concept in teaching; for instance teaching of steel structure.

These changes have allowed students greater freedom, greater time-saving and greater interest in the exercises. In addition they were able to solve simple as well as complicated problems related to projects normally assigned in their courses without the instructor's help. Students enthusiastically accepted this new system related to the approach of 'software to theory'.

This presentation of our evolution in computer-aided teaching may seem somewhat schematic; however, a more detailed version, giving added information, may be found in [1] and [2].

The experiments undertaken by our University in Mons had for some time attracted the attention of our colleagues in Eastern European universities with whom we maintained relations on a research level only.

Meanwhile the creation of Tempus (Trans European Mobility Scheme for University Studies) gave us all the idea for the possibility of a fast transposition of our model in teaching CAD to Eastern European universities. Tempus' main goals involve:

- promotion of the quality and support to the development of the education system in Eastern European universities;
- encouraging the growing interaction between partners of East and West Europe through joint activities and relevant mobility.

Even before the creation of Tempus, the idea of such a project and the needed collaboration of colleagues to get it started existed. However, lack of funds didn't allow its pursuit. Through acceptance of our proposal introduced in September 1990 titled 'Computer-aided design of structures including complex behaviour of materials and optimization' under JEP 0438–90, we surmounted last obstacle.

In Western European countries, the partners were chosen by the coordinator from universities collaborating with the Polytechnic Faculty of Mons in the field of Erasmus within a project devoted to Computational Mechanics or from partners known for their interest in CAD or optimum design based on previous scientific relations. In the Eastern European countries, partners were generally

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personal contacts of the coordinator (Prof. G. Guerlement) engaged in teaching FEM, computational technics or steel structures. Such partners agreed to work under the umbrella of their own universities. In the first year (1990–91) of the project, the partners were:

Western Europe
Polytechnic Faculty of Mons
(as leading university)
University of Liège (Belgium)
University of Pavia, Trento (Italy)
University of Essen (Germany)
University of Valenciennes (France)

Eastern Europe
Poland:
Technical Universities of Poznan and Cracow
Institute of Fundamental Technological Research (Warsaw)
Hungary: Technical University of Budapest

In the second year (1991–92) two types of new partners were involved. First, those who were presented by the initial partners, and secondly those introduced by an extension proposed by the coordinator (Universities of Compiègne (France), Milano (Italy), Bratislava and Prague (Slovakia/Czech Republic), Miskolc (Hungary), Nis and Ljubljana (former Yugoslavia), Karlsruhe (Germany), Athens (Greece), Joseph Fourier (Grenoble, France) and Ecole Nationale Supérieure d'Hydraulique et de Mécanique de Grenoble (France)).

Today, the contract is running among all partners but the results are specifically efficient for Eastern parners of the first year who have been working on the project for 16 months. Such length of time has enabled some results to be obtained. We will focus on these results later.

PRECISE AIMS OF THE PROJECT–TYPES OF ACTIVITIES

The aim of the project as previously stated was the introduction and/or development in Eastern European countries of the concept 'Computer-aided design' with high graphic facilities in the teaching of structural mechanics.

Besides this main objective, it is possible to find others with broad interest that were simultaneously realized, such as:

- improving the general process of education in structural mechanics for engineers of Eastern European countries and improving their preparation to a modern European industry;
- improving the design process for industrial structures with traditional materials (concrete and steel) or with new materials (composites). Introducing the practice of Eurocodes;
- improving Western knowledge of educational process and industrial structures currently existing in Eastern European countries;
- improving and unifying the contents of curricula in structural mechanics thus linking with similar existing attempts by Erasmus;
- exchanging teaching experiences and promoting computer-aided methods;
- improving the knowledge of foreign languages and the knowledge of the quality of life in Western European countries for people coming from Eastern European countries.

The planned activities were: establishment, development or improvement of small 'CAD centres' tailor-made for computer-aided design of structures. Some requirements have to be satisfied at a very high level: free access to students, graphic facilities, efficient pre- and post-processing. Such a task may be realized with:

- efficient PC for undergraduate students and possible upgrading of PC to work stations for PhD students involved in more advanced topics or for some specialized aims (such as automatized drawings for steel structures);
- additional hardwares such as plotter, screen hard copy and printer;
- efficient well-documented commercial softwares running on PC and perhaps on an improved level on work stations.

Of course efficient financial support from CEC in addition to a necessary personal effort of Eastern European universities was absolutely required.

The basic advised configuration for PC was a 386 PC with a co-processor, a sufficient capacity on disk (from 80 to 200 MB) and a colour screen. A commercial software named ALGOR, developed in the USA and largely used for the first teaching in FEM in the Polytechnic Faculty of Mons was proposed. This software includes possibilities for linear, non-linear, stability, static and dynamic calculations, is well-documented and has high facilities for pre- and post-processing. It is under continuing development and is rather inexpensive, with a special discount for universities.

A future possibility is the SAMCEF program developed in Belgium by SAMTECH company in collaboration with the University of Liege.

For steel structures more dedicated tools are proposed, such as CADIOS and CEPAO programs. CADIOS is a linear static and dynamic program devoted to three-dimensional steel structures developed in Belgium by ADEM company in collaboration with the Polytechnic Faculty of Mons. This program automatically prepares a validation of the structure at a very high graphic level. CEPAO is a plastic version for plane structures developed at the University of Liege.

In addition, some software developed by Eastern European universities such as ANKA software of the University of Cracow may be used.

Today, 'CAD centres' are specially developed in Poznan, Cracow and Budapest (first-year partners) where implementation of ALGOR, CADIOS and CEPAO are realized, or are under development. Besides these developments, financial support may be provided for books, journals, publications, teaching of foreign languages and translations of documents and manuals.

To support the development of 'CAD centres', three types of training were proposed in the first year of the contract:

- training missions for specialized scientists of Eastern European universities in Western European universities in view of supporting the future development of the 'CAD centres';
- visits from professors from Eastern European universities to Western European universities for discussions, information and comparison of curricula;
- teaching assignments of professors from Western European universities to Eastern European universities on topics either discussed in the contract or in relation to the Eurocodes.

In addition to scientists' training, organization of visits from Eastern European students to Western universities lasting three to six months was provided. Generally these students are in their last year of study or at the beginning of a Ph.D. degree. These students have been selected by their university on the basis of their knowledge, their fluency in foreign languages and their interest in the project.

Of course such a program requires much organization at all levels, and therefore all participants must be highly involved. Each institution has to choose a local coordinator responsible for local organization who must also work closely with the chief coordinator. The financial services of the Polytechnic Faculty of Mons must efficiently supervise proper transfers of funds among all those concerned.

Evaluation of the results of the project may be realized by visits from the chief coordinator and also by written reports from participants to local Tempus offices.

PRACTICAL EXPERIENCE AT THE END OF THE FIRST YEAR 1990–91

Total budget provided by CEC was 90 000 Ecus for Action I related to investment and organization and 65 000 Ecus for Action II in relation to the mobility of scientists and students. Two coordination meetings were organized in Belgium in February and March 1991. The efficiency of these meetings, despite the limited time period, permitted a normal evolution of the planned program controlled by four positive visits of the chief coordinator.

Action I: 15% of Action I budget covered the administration or organization cost and 85% covered investment in Eastern European countries in terms of hardwares and softwares previously described. The efficient running of the 'CAD centres' has been a successful challenge despite the limited time in which they were organized.

Action II: six teaching assignments with eight professors for a total time of sixteen weeks were realized on the different sites in Eastern European countries (Budapest, Poznan and Cracow). The topics of the lectures were:

- aims and methods of structural optimization—mathematical programming methods—optimization (University of Essen);
- elastic computer-aided design of space structures—theory and applications with emphasis on Eurocode 3—Workshop with CADIOS program (Polytechnic Faculty of Mons);
- plastic computer-aided design and shake-down of plane structures—theory and application with emphasis of Eurocode 3. Workshop with CEPAO program (University of Liege and Polytechnic Faculty of Mons);
- problems and methods in structural optimization—reinforced concrete special features of European codes (University of Pavia);
- optimal design with orthotropic materials (University of Trento).

Ten training missions with nine scientists for a total time of eight months were organized. Five visits by five professors of Eastern European universities and a total time of eight weeks provided pedagogical discussions, comparisons of curricula and fruitful exchanges. In addition these have set the stage for access to a special European Masters Degree for candidates from Eastern European countries spending their last year of studies in Western Europe.

Seventeen students were accepted for a total time of 57 months in Western European universities with free access to lectures, CAD possibilities, library, and so on. Some of them participated actively in research work.

A more direct collaboration between Poznan and Mons was concretized by a participation to the East–West Congress on Engineering Education held in Cracow in September 1991.

The main difficulties during this first year were:

- teachers at Western European universities having no sufficient time, and thus it appears important to limit teaching assignments;
- difficulty of organizing efficient training in foreign languages for students of Eastern European countries: it seems necessary to use only English for student communication. So organization of a common diploma is difficult and will be restricted to students with previous efficient language training;

- shortage of accommodation for students in some Western European universities, specially in Germany;
- some difficulties with financial transfers, communications (phone and fax) and specially obtainment of visas for stays longer than three months. A general action from European Tempus office would be appreciated for visas.

PRACTICAL EXPERIENCE FOR YEAR 1991–92

For this second year, the budget of Action I was 130 000 Ecus. So investment may be pursued for continuing development and equipment of 'CAD centres'. With some new Eastern European partners (University of Miskolc) efficient exchange was immediately arranged.

With others, starting up the contract was problematic, especially in terms of mobility of students, for example with partners from the Czech Republic. The starting up of the contract was equally unpleasant in former Yugoslavia due to the political situation.

Such problems may stem in part from the large number of participants. Nevertheless the enthusiastic, personal and continued action of initial participants is greatly appreciated by the chief coordinator. In this field, some activities initiated by the Tempus JEP bear attention.

University of Poznan: organization of a two-day seminar in April 1992 devoted to CAD aiming to present FEM and possible practical applications to Polish local industry. Development of softwares involving Polish standards in CAD for the steel industry. Preparation and study of a common university degree fulfiling the requirements of Polish curriculum and a European Masters Degree in Computational Mechanics at the Polytechnic Faculty of Mons to be initiated in the coming year.

University of Cracow: Organization in June 1992 of a three-day seminar devoted to 'Computer-aided Analysis in Student Teaching and Training'. This seminar will be supported by Tempus Action I and will constitute a membership session for fruitful exchange of teaching experiences.

University of Budapest: Close collaboration with Belgian universities is under development in the field of steel structures teaching. Softwares following Hungarian guidelines, now in preparation, will be presented to industry at a seminar of CAD programs to be held in September 1992.

These actions show the success of the development of the CAD concept initiated by the Tempus JEP.

CONCLUSIONS

Aims, practice and initial results of a Tempus engineering JEP devoted to CAD were described. It seems that such a JEP project has constituted a successful challenge. It is hoped that after the initial three-year pilot phase ending August 31, 1993, CEC will provide new possibilities for continuing the improvement begun in teaching through the use of the CAD concept.

Such a concept cannot be neglected for it goes beyond the confines of the university into the industrial development of the country itself.

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