LINK BETWEEN CAD SYSTEMS AND ANALYSIS PROGRAMS AS A STEP OF AN INTEGRATED APPROACH OF THE BUILDING PROCESS

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Abstract

The link between CAD-systems and FE-programs seems to be very promising because they use in some sense the same data: geometry as well as some information about mechanical properties are normally contained in the CAD-system. The inclusion of FE entities in the Initial Graphics Exchange Standard (IGES) may be an illustration of this statement. Experience will be reported in linking CAD-systems and FE-programs on mainframe as well as on microcomputers. Access to the database and programming facilities offered by the CAD-system are crucial. We believe that our experience concerning interface possibilities is also valuable for other situations (e.g. planning of the building process).

Introduction

In these days pre- and postprocessing capabilities of finite element programs are considered as essential features. Mainly two aspects are stressed: a fast, accurate preparation of input and a selective graphical presentation of results. Of course, during the last years, a number of pre- and postprocessors are developed for specific FE-systems. (SAP 6/7, SDRC-SUPERB, SYSTUS, ...) [1]. These processors make an excellent use of the inherent possibilities of the FE-programs, but there is no way out to manufacuring ...

Moreover, some general pre- and postprocessors (FEMGEN/FEMVIEW, PDA-PATRAN/G, SUPERTAB, ...) [2] have been written, with interfaces to different FE-programs. All this software is coming also available on engineering workstations (Apollo, Sun, IBM PC RT, ..), as well as on personal computers. A third approach is to link FE-programs to powerful existing CAD-systems, making directly use of the possibilities of interactive manipulation of graphical presentations. Another obvious advantage is the opening to horizontal integration in the design process, while these systems have in general some modules for manufacturing purposes. Also important is the expected coupling of expert systems and CAD, e.g. in a preliminary design phase [4].

It can be mentioned that nowadays many modern FE systems can dump their graphical results into CAD-systems, however without making use of the inherent possibilities offered by these systems.

Link CADAM-SAP4 [3]

CADAM (Computer Graphics Augmented Design and Manufacturing) is growing up from originally a 2,5D-basic module to a powerful CAD system with 3D-wireframe, 3D-surface and, in a near future, 3D-solid presentation. Several modules can be added, e.g. modules for architectural design, NC, piping, ... There is also a MESH-module (Fig. 1) that can create finite element entities like nodes and elements making full use of procedures to copy, translate, mirror, scale, ... any predefined group of elements. There is also a mesh generating facility. Attributes can be associated to elements and nodes.

All relevant information can be stored in the database as a splitfile which is transformed by the utility Cadam To MeshFile (CTMF) into a meshfile. What we have described until now, is supplied by the program developer. The user has to write his own FORTRAN-programs for completing the geometrical information with material characteristics and load-conditions. Realisation of an interactive session between the CADAM-database and the users programs is possible. The Cadam Macro Geometry Capability (CADMACGM), a part of the Geometry Interface Module (GIM), allows an interactive program-execution through menus in dialogue-mode or parameterlists in display-mode. This interaction must be programmed in "Assembler-like language".

Our experience with this facility was somewhat disappointing: we have not realised our initial intention to freely construct loops, to mix dialogue- and display-modes, to setting up actionmenus, to select nodes and elements on display for further characterisation ... This was mainly due to the fact that all the information for the FORTRAN programs has to pass through a one-dimensional vector.

As a result of the macro-programs a number of temporary macro-files are produced. These files must be combined with the meshfile to an inputfile for the envisaged finite element program, in our case SAP4.

In the postprocessing phase, we can use the macro- and meshfacilities in an inverse way. The old meshfile is changed by increasing the nodal coordinates of the original structure by the scaled displacements. The utility MeshFile To Cadam (MFTC) translates the new meshfile to a drawing in the graphical database. Making use of CADMACGM and CADCD (Interface to Cadam

Database) we have developed several presentations of stress results. The user can make a choice between the following visualizations:

- vectorplot of principal stresses (plates and shells)
- contours of Von Mises equivalent stress (plates and shells)
- contours of moments (plates).

All programs run on a IBM 4341 computer with VM/CMS operating system.

Development of a general postprocessor [5]

It was our intention to develop for research purposes a postprocessor with an open structure so that interfaces to a variety of finite element programs can easily be written and adapted in the future. The postprocessor must run on a IBM-compatible PC and has to be, as much as possible, hardware independent. A user-friendly environment must be created, what implies a reasonable response time and the possibility to make a choice between different visualizations.

The required independence between analysis programs on one hand and the graphical part on the other hand causes the necessity for definition of a neutral file format (Fig. 2).

The "neutral file" is split into two parts:

- geometric file with nodal coordinates and element definitions
- file with results of the analysis programs.

Each file has different sections, preceded by a header and a statusline.

The contents of a section are identified by the first four characters of the header. Further specification of the section is made by a series of numbers in the statusline: elementtype, loadcase or timestep, ... The subsequent data lines consist of a number of columns, each representing a specific result (e.g. membrane stress in x-direction ...).

Because every section can be recognized by the header and the statusline, further extension of the neutral file is not compromised by a rigidly imposed sequence of data.

Interfaces to this neutral file are already written for SAP86 (a PC-version of SAP4) and PLANET (a 2D-finite element program for elastoplasticity). They have proven the easy access to the neutral file structure. To free the graphical session from lengthy intermediate calculations, we have foreseen in the neutral file a place for all possibly desired results (principal stresses, equivalent stresses, reinforcement moments ...). If these results are not contained in the normal output of the analysis program, the interface has to provide for it.

A number of conversion routines can be supplied to users who want to write an interface from their (personal) program to the neutral file [5].

For the graphical session we dispose of the following facilities:

- Professional Colour Graphics system of IBM: direct programming of the corresponding controller has the advantage of very fast execution because of the hardware-implementation of some (also 3D) graphical functions. Draw-backs are the tedious programming in machine-language and the orientation to a video system that seems to be not the standard (what is EGA) for good resolution colour graphics on PC. Also printers or plotters can not be addressed in this way and drawings not stored.
- A GKS-package on PC: a program based on GKS can communicate with different "workstations", making application programs independent from any graphical input or output device. The GKS-program is linked to a "Virtual Device Interface" (VDI) that can address a driver for a specific device. A disavantage is that the GKS-package distributed by IBM has only drivers to IBM peripheral units.
- The AutoCAD-package: this program has become the defacto standard for CAD on PC. The success can be explained by the open structure: the user can easily create his own commands (in a LISP dialect, AutoLISP) and menus, so composing this "own" CAD-system. An advantage is also the availability of a lot of drivers for I/O-devices. Drawings can be stored and DXF- and IGES-files allow easy access to the geometrical database under program control. For all these reasons, our final preference was AutoCAD. The use of AutoCAD instead of GKS delivers us also from programming a number of procedures, like zooming, making menus ...

For the user a graphical session starts with specification of a plane in the 3D-structure, where results processing is wanted.

Then he can invoke a series of commands, corresponding with different visualizations:

- displacement vectors
- principal stresses
- contours (of $z = f(x,y)$)
- colour plots (area fill) (of $z = f(x,y)$)
- isometric presentation with shading and hidden line removal (of $z = f(x,y)$)

The user can zoom into details for investigation of local stress concentrations. Every command calls up a (FORTRAN) routine calculating the desired presentation (e.g. contour lines ...). In these routines DXF-files are made and passed to the AutoCAD-system. Earlier attempts to program all these calculations in AutoLISP were rejected because of too slow execution: indeed AutoLISP is treated by an interpreter instead of compiled in machine code; also a read-procedure using AutoLISP is cumbersome. So we use AutoLISP only for adding commands to AutoCAD and not for constructing graphical figures.

Conclusion

CAD-systems can be used in the preliminary design phase, in structural analysis for pre- and postprocessing purposes, for verification according to regulations, in planning, etc...

In Japan large construction firms like Shimizu, ... are developing their own integrated CAD-systems [6].

Essential are the possibilities to interact with the database and the facilities for the user to create his own menus, commands, libraries, ... This seems to be an important criterium for selection of an appropriate system.

We have reported about our experience in two practical cases and we believe that this information can be useful for other program developers.

References

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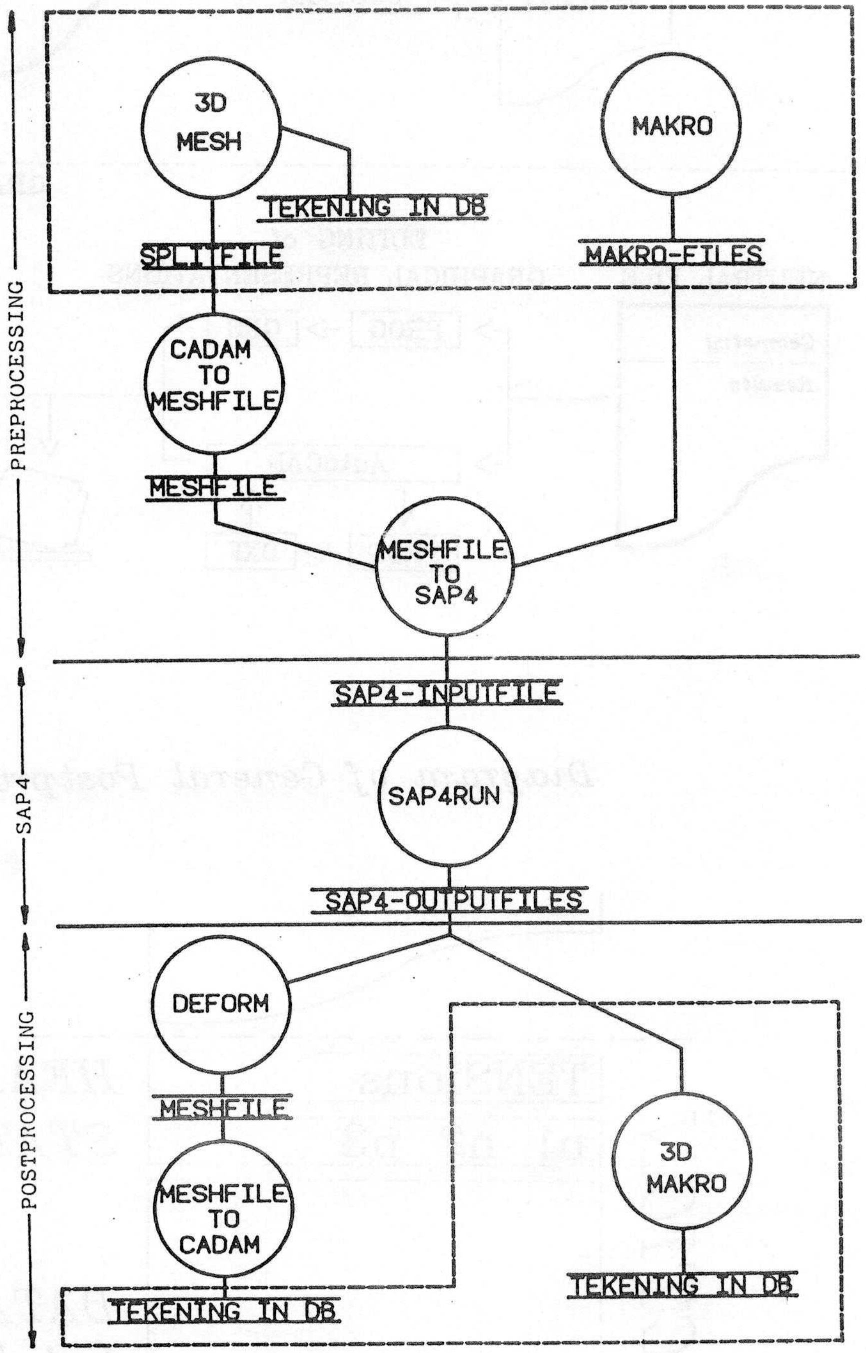

PREPROCESSING
SAP4
POSTPROCESSING
3D MESH
TEKENING IN DB
MAKRO
SPLITFILE
MAKRO-FILES
CADAM TO MESHFILE
MESHFILE
MESHFILE TO SAP4
SAP4-INPUTFILE
SAP4RUN
SAP4-OUTPUTFILES
DEFORM
MESHFILE
MESHFILE TO CADAM
TEKENING IN DB
3D MAKRO
TEKENING IN DB

Fig. 1

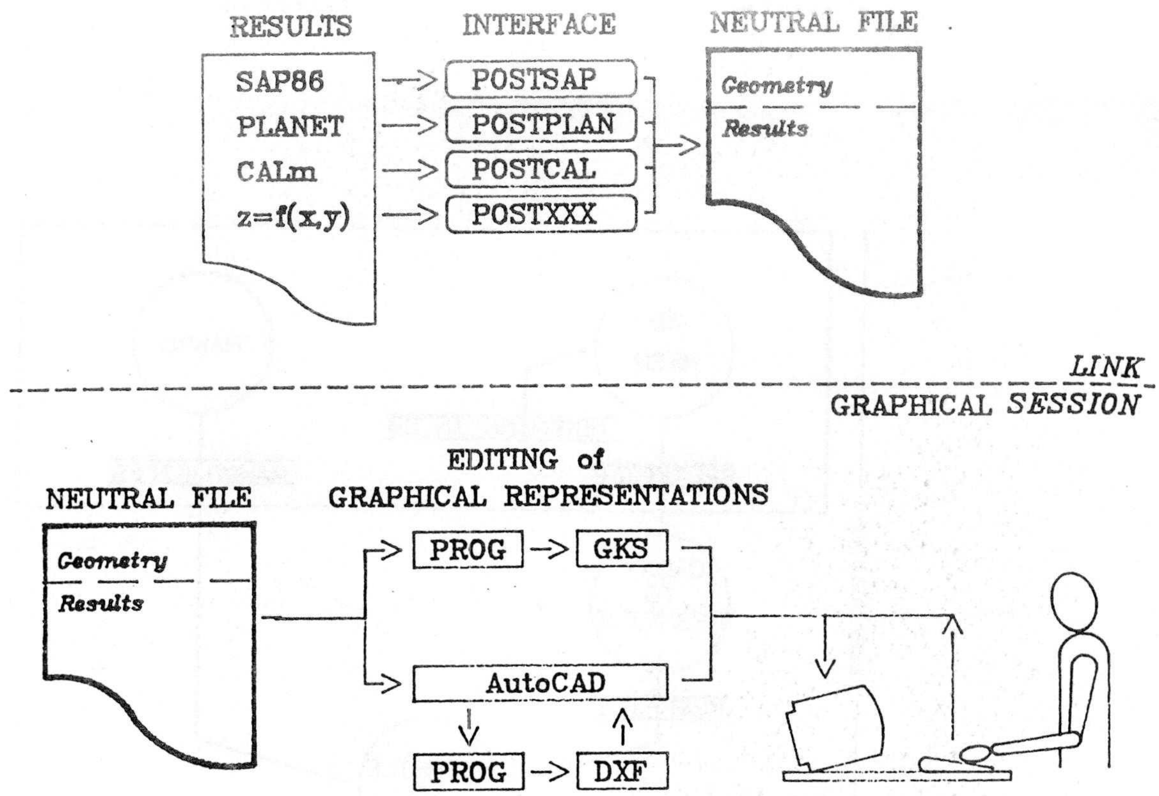

Fig. 2

Diagram of General Postprocessor

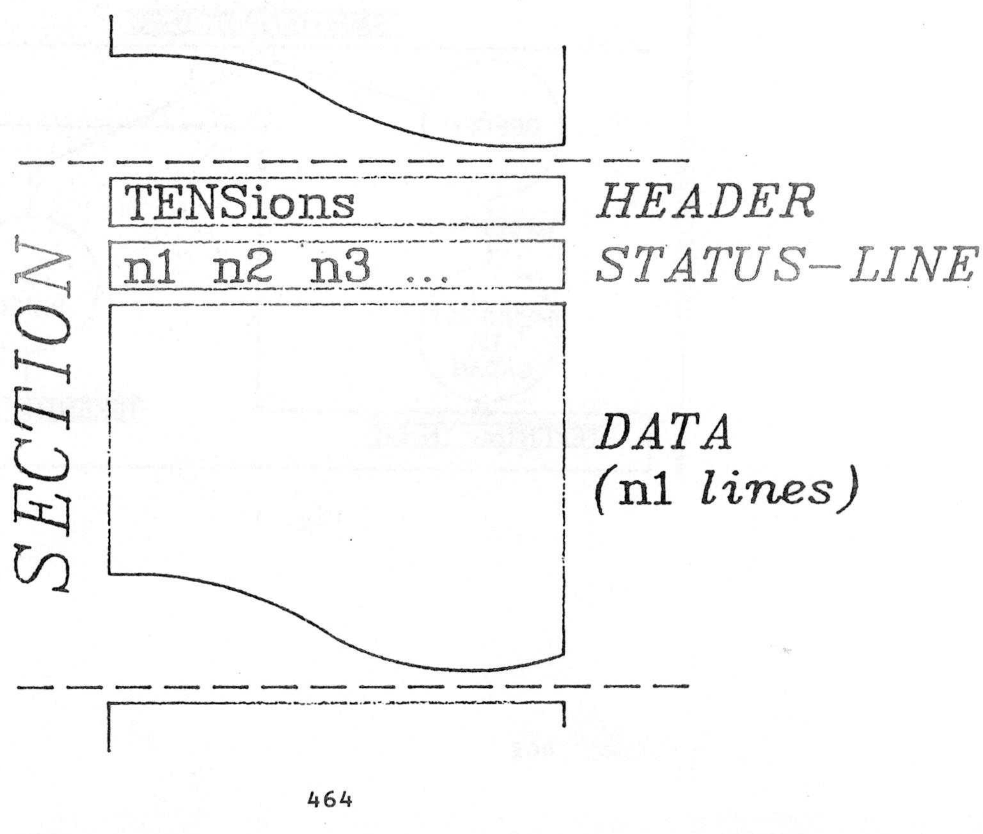

Fig. 3