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AUTOMATED JOB PREPARATION FOR SOLVING ENGINEERING PROBLEMS ACCORDING TO THE METHOD OF FINITE ELEMENTS THROUGH THE PROGRAM SYSTEM VIMKE

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Abstract. VIMKE is a computer system for practical application of the method of finite elements. It is mainly designed for testing the stressed and deformed condition of deformable bodies under various types of impact. The automated preparation of jobs for solving engineer problems through the system VIMKE is examined at the present publication.

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Key Words: method of finite elements, automated sysytems

1. The program system Vimke

The method of finite elements (FEM) is a numerical method for solving the partial differential equations that illustrate the behavior of a deformable solid body and it is one of the most popular methods for testing the stressed and deformed condition of complex structures in the systems for computer aided design. As it is required by the method, the tested structure is fragmentated into, the so-called, finite elements, i.e. solid bodies of simpler geometry, such as triangles, quadrangles, tetrahedrons etc. The geometry of each finite element is specified by assigning the coordinates of the units adjacent to it.

After solving the problem through FEM, values of functions are achieved for the units and they show the stressed and the deformed condition of the tested structure.The fragmentated structure must be specified by: the coordinates of all the units (geometrical information); the adjacency of the units to each finite element and its type (topological information). Some more details must also be presented, such as: the values of the parameters, defining the properties of the materials, coefficient of elasticity, temperature expansiveness coefficient etc., as well as some geometrical characteristics (moment of inertia, thickness of the thin-walled elements etc., specifications for the fastening of the structure, loading conditions); what problem is there to be solved and in what conditions; what results are to be worked out.

The general look of the program system is presented on fig. 1.

Fig. 1

The complex program system VIMKE comprises the following programs:

- SUPERVISOR - prepares the files for the operation of the system, distributes the resources and manages the operation of all programs .
- SIMKE-for strength and deformation testing of random structures: two-dimensional and three-dimensional, solid and thin-walled, structures with slabs and with beams. For problems with two-dimensional stressed and two-dimensional deformed condition, calculations in the over-elastic domain are also possible (if there are plastic deformations); solving optimization and contact problems.
- RODET - program for calculation of strength and deformation of rotationally symmetric details at random loading in the elastic and over-elastic domain;
- POLE - this program analyses the stationary and non-stationary heat transfer in two-dimensional and three-dimensional domains. The same programs have the capacity to analyze magnetic and electric fields. The program solves the differential equation of Laplas (in particular that of Poason).
- FEDAT - preprocessor for preparation of input data into dialogue mode for the programs SIMKE, RODET and POLE. It has the capacity to generate, control, optimal numbering of the units and elements and graphical illustration of the network of finite elements. Due to it the examined domain is fragmentated into finite elements;
- FEAN - postprocessor for examination and analysis of the results calculated by the programs SIMKE, RODET and POLE in dialogue mode.
- FEGRAF - a computer graphics program.

The programs SIMKE, RODET and POLE that implement the method of finite elements operate in script mode and the data entry for them is performed through a problem oriented input language. The preprocessor FEDAT, the postprocessor FEAN and the graphic processor FEGRAF operate in dialogue mode.

- INPUT PROCESSOR - it makes the input of entry data, the recording in the communication domain, the creation of the file with the problem description compatible by means of an input language.

- INTFEM - program for communication between the system VIMKE and other systems that implement FEM.

The COMMUNICATION DOMAIN contains all the information of the system and it is accessible to all programs.

2. Supervisor.

For preparation of the files of the system VIMKE, distribution of the resources and management of all the above appointed programs is worked out in the program media DELPHI 4, application SUPERVISOR, operated by Windows. While it is operating, other Windows operated applications may be started. The user may provisionally work in DOS, where other dos managed programs may also be started.

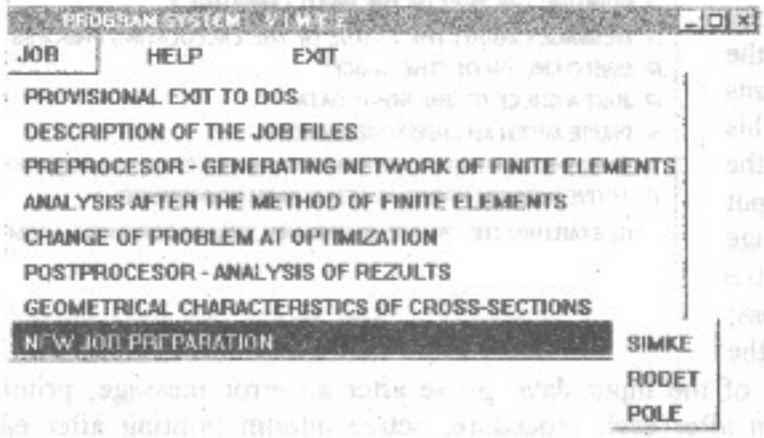


Fig. 2

The application has 3 menus "**Job**", "**Help**" and "**Exit**". The main menu "Job" (fig. 2) gives access to all functions of the system VIMKE. It includes such command as "Provisional exit to DOS" (for those programs that are DOS operated DOS-shell is started); "Description of the job files"; "Preprocessor" (the program for generating network of finite elements is started - FEDAT); "Analysis according to the method of finite elements"; (the programs for analysis according to FEM are started optionally - SIMKE, RODET or POLE); "Change of problem at optimization"; "Postprocessor - analysis of results" (the program for analysis of the achieved results is started - FEAN); "Geometrical characteristics of cross-sections"; "New job preparation". After completing the started program, the management goes back to the application.

The SUPERVISOR creates a file Initvimk.vin to manage and coordinate the operation of the whole system. The information managing the analyzing programs and the main files of the problem are recorded in it: the file in which the job prepared for analysis according to FEM shall be recorded (following the instructions of the input language) with the filename extension of ".VHD", the operating file which the different programs are using with the filename extension of .VRB and the file for printing the achieved results with the filename extension of .VLS.

The command **"Description of the job files"** is chosen when it is necessary to either create new or edit an existing Initvimk.vin file. If the file exists in the open dialogue window (fig.3) the given parameters are being loaded and the user may make whatever changes he wishes. If the file does not exist, it is necessary to input all the data. Some options that may affect the work of the analyzing programs may be selected in this window: printing the text of the input language; . message about the status of the calculating process; switching on of . "the clock"; just a check of the input data; pause after an error message; printing statistical information after each procedure; active interim printing after each procedure; restarting the program for analysis according to FEM. The shown active fields are the implicit options. Either new names are recorded in the fields for file names, or the relevant buttons are activated ("...VHD", "...VRB", "...VLS") to open the standard dialogue window "Open" by which the desired file is selected.

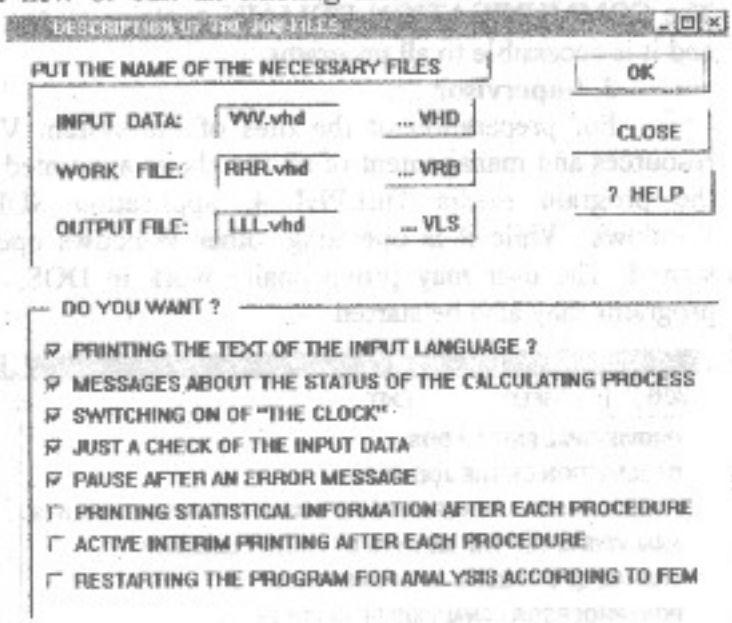


Fig. 3

3. Input processor

The software applying FEM is highly sensitive to the design of the dialogue with the user. That is related to a complex preparation of huge amounts of information and the difficulties with its checking and correcting that may sometimes take months.

The specific character of FEM demands a compromise between the interactive and the script mode of input of data. Once recorded, the input data may easily modified or used for solving other similar problems, due to the fact that generally the study of a single problem requires manifold performance of the programs for analyze according to the method of finite elements.The purpose of this is elimination of the mistakes of the entry data preparation and the study of a large scale of options.

A problem-oriented language, a subset of the language-shell is developed for the input of entry data. The vocabulary of the language is adapted to the specific character of the method of finite elements. Suitable words from the relevant natural language (Bulgarian, English etc.) are selected for commands. The use of live text items and sets of items for descriptors, commands and aims is a convenient option which is in use in other descriptive languages as well. The new thing here is the option for use of arithmetical expressions, lists, cycles, tables and modified chains. For the application of the language a problem independent translator-shell is worked out. Its adjustment for work is performed by controlling models (they are carriers of the information that controls the process of syntactic and semantic analysis and generates the operation command), recorded in the knowledge base of the system.

The input data for the program system VIMKE are grouped in logical blocks: "General data"; "Topological information"; "Geometrical information"; "Material constants"; "Kinematic and static limit conditions"; "Formulation of the solution and the required results".

For preparation of a new job for analysis according to FEM or editing of an existing one (the name of the file is to be given) the command "**New job preparation**" must be activated from the SUPERVISOR. It starts the input processor - a Windows operated application designed in the program environment of DELPHI 4. The logical blocks of the entry language have their corespondent divisions in the application.

For example, fig. 4 shows a part of the first dialogue window of the "GEOMETRY" division which corresponds to the

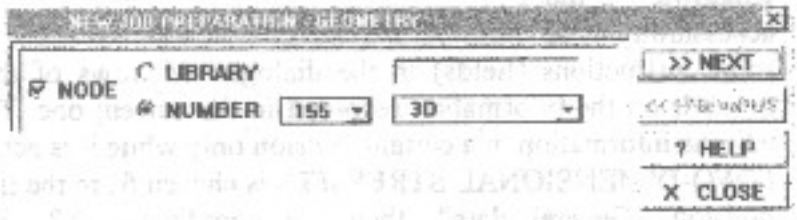
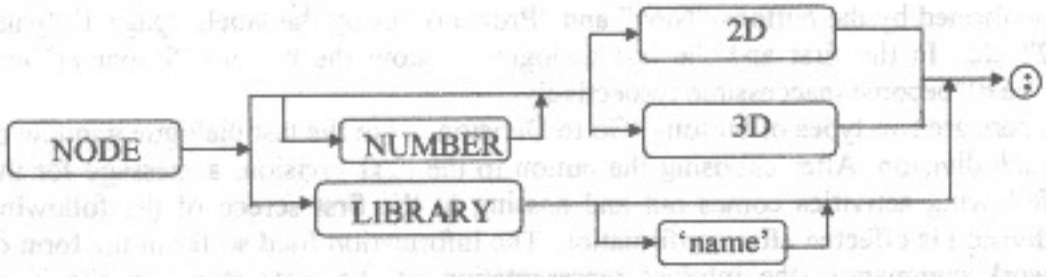


Fig. 4

logical block "Geometrical information". Input of information for the instruction UNITS is performed here and it has the following syntactic diagram:



The information in this part of the dialogue window shall generate the following instruction of the input language:

NODE 155 3D ;

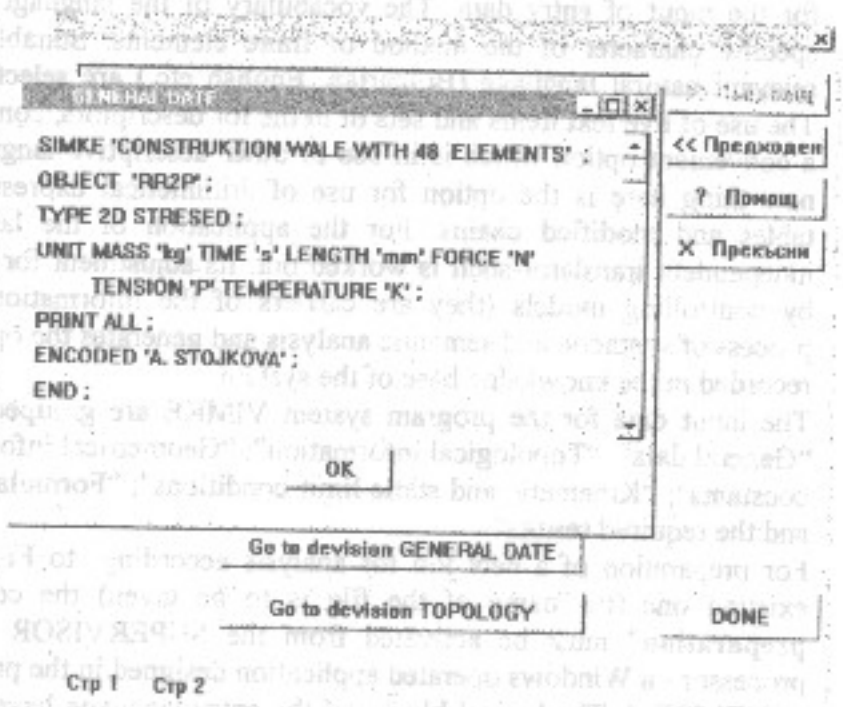


Fig. 5

The input processor comprises both operating modes - operation in script mode by means of an input language and operation in interactive mode. Due to the strong context dependability of the instructions of the input language, respectively of the information recorded in the dialogue windows, the accessibility of some instructions (fields) in the dialogue windows of the following divisions depends on the information recorded in the current one. Therefore the user may edit the information in a certain division only while it is active. For example if 2D (TWO-DIMENSIONAL STRESSED) is chosen from the list field "TYPE" of the division "General data", then the coordinates X2, Y2, Z0, Z1 and Z2 automatically become inaccessible for the instruction "TRANSFORMATION" of the division "GEOMETRY". While if any of the three-dimensional types is chosen for object, then those fields become accessible and third dimension coordinates may also be given. Passing from one window to another is either performed by the buttons "Next" and "Previous" or by the labels "page 1","page 2" etc.. In the first and the last dialogue window the buttons "Previous" and "Next" become inaccessible respectively.

There are two types of buttons "Go to Division ..." in the last dialogue window of each division. After choosing the button to the next division, a message for the following activities comes out and passing to the first screen of the following division is effected after confirmation. The information filed so far in the form of work commands (the internal representation of the instructions in the input language) is recorded in the communication domain and the instructions generated by the input language in the appointed file with the extension of .VHD.

If the button leading to a previous division is selected a window with the generated instructions shows up - the user may make corrections and if he wishes the corrections may be registered. directly in the communication domain. Fig. 5 demonstrates how after choosing the button "Go to division GENERAL DATA" the generated sequence of instructions for this logical block shows up.
Some of the instructions are obligatory and they are given in the dialogue windows in "Bold", while those that are not obligatory are pale and given in "Italic" and their fields are inaccessible. If the user wants to include a not obligatory instruction in the description of the problem and activates it, its font turns to Bold and its fields become accessible. Radio buttons and control fields are used to activate and select the chosen instructions and parameters and list fields for beforehand negotiated parameters. Limits are given for almost all numerical values of the parameters. If any of the given values exceeds the limit, after leaving the field the value becomes zero or the closest implied one.
In the sequence of data (instructions) there are such that may be repeated many times. For example in the division "GEOMETRY" such group are the instructions 'COORDINATES", "SCALE", "TRANSFORMATION", "CONVERSION" and "TABLE".
The division "GEOMETRY" has two major dialogue windows and by the button of the same name a group of four new dialogue windows is started and in these windows information may be entered repeatedly.
The button "CLOSE" returns the control in a previous division without recording of the so far filed information, while the button "HELP" activates help information. The button "DONE" of the last dialogue window in the last division finally records the filed information in the communication domain, and the generated file with the instructions in the input language to the pre appointed place after which the control is passed over to the SUPERVISOR. If the cursor is held over any of the instructions, fields or buttons a prompting text pops up which makes the use of the system easier.

4. CONCLUSION

The preparation of a job for analysis through the method of finite elements requires a complex preparation of huge amounts of information, hardships with the filing in of the information, checking and correction, which in some cases may go on for months. The development of the devices represented herein renders this complex long and arduous process automatic thus minimizing the mistakes in the filing in of the input information and giving opportunity for repeated performance of the programs for analysis through FEM with the purpose of testing various options. The programmer may concentrate in the fulfillment of his immediate tasks without losing precious time for preparation and filing in of information.

Alongside with the system some multimedia applications are developed to make the preparation of a job and the operation of the system faster and easier: "User's manual for the program system VIMKE" and "Input language of the program system VIMKE". The representation of the material through contemporary multimedia facilities gives wider opportunities to specialists to interactively control the content and flow of information and without attending specialized courses to prepare their jobs and use VIMKE.

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