COMETa 2012
1st INTERNATIONAL SCIENTIFIC CONFERENCE
28th - 30th November 2012.
Jahorina, B&H, Republic of Srpska
University of East Sarajevo
Faculty of Mechanical Engineering
Conference on Mechanical Engineering Technologies and Applications

ZBORNIK RADOVA

PROCEEDINGS

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IMPROVEMENT AND INTEGRATION OF FEM SOLUTION USED FOR R&D INTO FEMAP

Marko Topalović[1], Miroslav Živković[2], Nenad Busarac[3], Snežana Vulović[4]

Abstract: This Computer simulation and structure behavior researchers often develop their own FEM solution for testing new material models, element types or numerical procedures. Improvement and integration of user developed FEM solution into FEMAP which is state of the art pre and post-processing software has a purpose to enable researchers to focus more on their scientific investigation by reducing tedious workload that is result of inadequate UI of user developed solver. Developed methodology presented in this paper enables researchers to create analysis CAD model in FEMAP, perform FEM analysis testing new material models, element types or numerical procedures in user developed solver and view results back in FEMAP. Connection between FEMAP and user developed FEM solver is performed by automatic, programmatic customization of FEMAP and development of new features in FEM solution. These new features automate many tasks in model preparations. As a result, FEM solver looks and operates as integral part FEMAP and its functionality is greatly improved.

Key words: computer simulation, finite element method, pre-processing, post-processing, software customization

1. INTRODUCTION

Computational methods [1] such as Finite Element Method (FEM) [2] in particular, are used for stress analysis in many fields of engineering. Wide spread of FEM means its taught on many engineering universities as well as used in many research institutes. Numerous software companies developed their FEM solutions which are widely used by many manufacturing companies. Commercial FEM solvers have good pre-processing (geometry modeling and mesh generation) as well as good post-processing (visualization of results) [3]. Downside of commercial software is no or limited access to program code which hurdle independent researchers in testing behavior of new material models, element types or numerical procedures. To have advantages of both approaches, we used combination of researcher developed FEM

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solution and commercial program used for pre- and post-processing. In this paper we described linking of our R&D FEM solver with commercial program for pre and post-processing FEMAP. Second section of this paper describes current state of implementation of R&D FEM solution in Engineering Software Lab. In the third section we described methodology used to customize FEMAP UI and create new C++ program that links our software solution with FEMAP. In the forth section of this paper we described new functionality of FEM solution integrated in FEMAP. In the conclusion we discuss benefits of new methodology.

2. CURRENT STATE OF IMPLEMENTATION OF R&D FEM SOLUTION WITH FEMAP

FEMAP is software used to create FEM models for different engineering problems [4],[5] and to display analysis results. FEMAP is solver neutral and provides comprehensive pre- and post-processing support for all of the major commercial solvers on the market, such as NX Nastran, which is built in FEMAP, and others. FEMAP can create input files for those solvers and it also can read result from their output files.To use FEMAP with unsupported solvers, such is our R&D FEM solution, users need to save analysis model into ASCII file called FEMAP Neutral (*.neu), which serves as universal data transfer interface (input and output) between FEMAP and any other program. Before analysis neutal file is generated manually by user from FEMAP an after FEM analysis R&D solver generates neutral file which is also inputed manually by user into FEMAP. FEM solver uses its own input file, which uses data from FEMAP Neutral, supplemented with data inputed by researcher needed for his specific research. Significant number of operations needed to perform FEM analysis with R&D solver is tedious work of FEM solver input file preparation and generation, manual starting of FEM analysis and loading results. We automated all these operations.

3. CUSTOMIZATION OF FEMAP USER INTERFACE

FEMAP allows users to customize its UI trough options accessible trough main program menu by choosing *Tools->Toolbars.* User can create *User Commands* which can be used for starting user's own program from FEMAP. Once created, *User Command* can be placed in main menu, some sub menu or any toolbar. In our case we want to create user command that, when clicked, starts out FEM solution.

For programmatic customization of FEMAP we used FEMAP Application programming interface (API) [6] that allows users to customize FEMAP to meet their specific needs and contains hundreds of methods that can be called from Visual Basic, VBA (Excel, Word, Access, ...), C, or C++.

To customize FEMAP we needed access to application object [6]. We developed solution that programmatically create FEMAP *User Command* and place it in FEMAP main Meny Bar by calling FEMAP API methods. Our next step was to create Windows Installer Package which unpacks FEM solution after which automatic programatic customization is performed.

4. AUTOMATION OF ANALYSIS PROCESS USING FEMAP AND R&D FEM SOLUTION

The procedure to convert FEMAP model into research solver input file begins with creation of FEMAP neutral file.

After the FEM solution is started from FEMAP, there are several actions it performs:

- attach itself to FEMAP using FEMAP API
- create FEMAP neutral file using API methods
- read data from FEMAP neutral file

Creation of R&D solver input file is a relatively straightforward process in which translator program writes data obtained from FEMAP neutral file into solver input file. Some additional analysis parameters (not present in FEMAP neutral file) can be inputted in translator. Translator can start FEM analysis, from within FEMAP, of previously generated input file. Creation of solver input file without starting analysis is used when researchers use one computer for modeling in FEMAP, and server or a cluster for FEM analysis. Batch file is generated which is used to start R&D solver, which is a console application programmed in FORTRAN, and feeds it with previously generated input file. To start batch file we used *_spawnl* method which will start analysis process and pause execution of translator segment of our FEM solution until analysis in R&D solver is finished. When analysis is finished, execution of FEM solution will continue and new pop-up dialog will be created alerting user that analysis is finished and that results are available for loading.

5. RESULTS AND DISCUSSION

Translator program, customization program and R&D solver (*pak.exe*) are all part of our FEM solution [7]. Windows Installer Package is used for FEM solution installation. Users need to start setup program and if they desire, change installation directory. Everything else is carried out automatically and users are not aware of FEMAP customization process that runs in the background. After the setup is complete users can start FEM solution called PAK from FEMAP Main Menu (Figure 1).

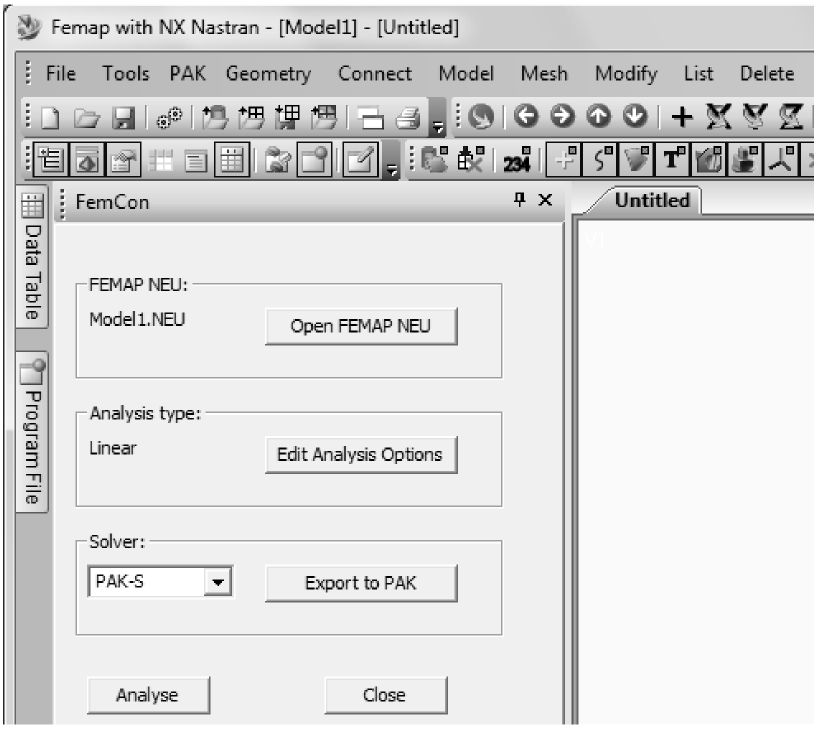

Fig.1 R&D FEM solution integrated in FEMAP

Following simple example is used to demonstrate new methodology [8]. Example shows the application of iterative arc-length method, follows the history of deformation of the structure with snap-through and snap-back effects. Circle arc having unsymmetrical supports is loaded by force (Fig. 2). Force increase causes large displacements of a structure. Material is isotropic and elastic.

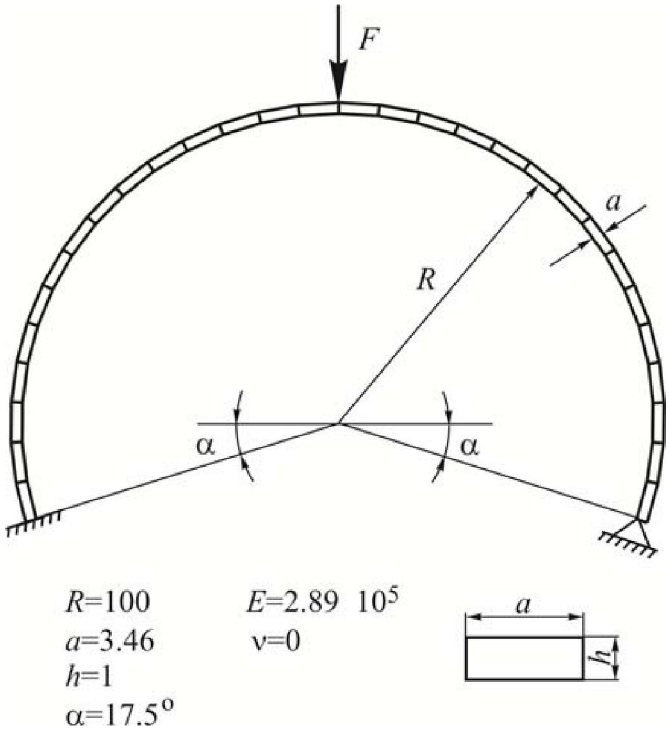

Fig.2 Arc analysis in R&D solver PAK

Modeling in FEMAP is described in FEMAP User Manual [6]. First step is definition of material with characteristicks shown on Figure 2.

Youngs Modulus, E is 2.89E5

Shear Modulus, G is 0

Poisson's Ratio, ny is 0

Second step is property definition, in this case users should chose ***Membrane Plane Elements*** with ***Thickness T1*** equal 1.

Third step is geometry creation, in this case two arcs defined by their center, start and end point.

First circle arc:

Center x: 0 ; y: 0 ; z: 0

Start x: 97.022 ; y: -30.951 ; z: 0

End x: : -97.022 ; y: -30.951 ; z: 0

Second circle arc:

Center: x: 0 ; y: 0 ; z: 0

Start: x: 93.722 ; y: -29.550 ; z: 0

End x: - 93.722 ; y: -29.550 ; z: 0

After creation of two arcs, users need to make a surface from them.

Fourth step is mesh generation. In this step users need to set mesh size for surfaces then select surface to mesh and finally, select property defined in step 2.

Fifth step is constraints definition. Unsymmetrical supports (Fig. 2.) are modeled by constraining translation of both lowest nodes on the left side and inner lowest node on the right side in X and Y direction. Permanent constrains are set for all nodes disabling translation in Z direction and rotation in all directions.

Sixth step is definition of load. Nodal force of -1 in Y direction is set on top node. After definition of load, model is ready for analysis (Fig. 3).

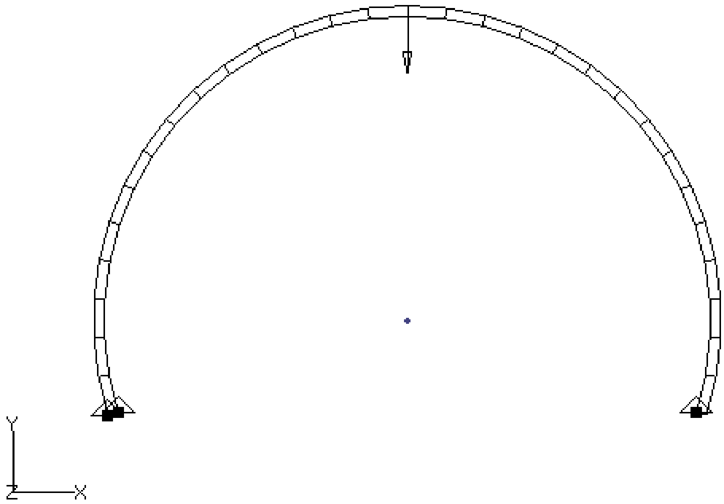

Fig.3 Model in FEMAP ready for analysis

Researchers can start translator program by clicking on a "PAK" option that is added in FEMAP Main Menu (Fig. 1). When started, translator attaches itself to top leftmost panel of FEMAP (Fig. 1). Now researchers need to set up analysis parameters by clicking on button ***Edit Analysis Options*** (Fig. 1). First parameter is ***Analysis type***; in this case ***Total Lagrangiane*** (Fig. 4).

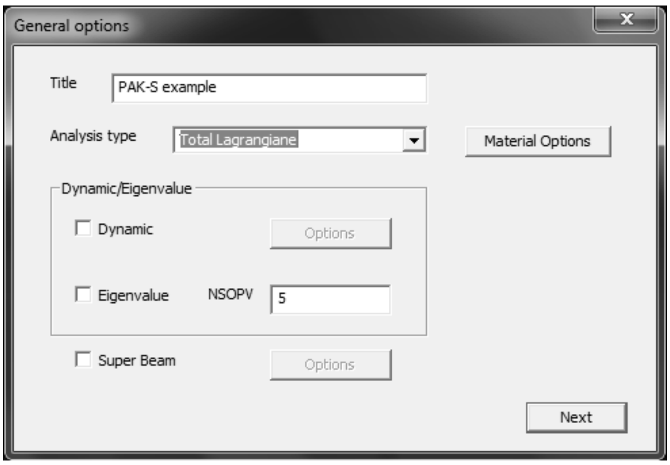

Fig.4 Translator dialog for selecting analysis type

In the next dialog researchers need to define number of steps (in this case 180) and time step increment of 1 (Fig. 5).

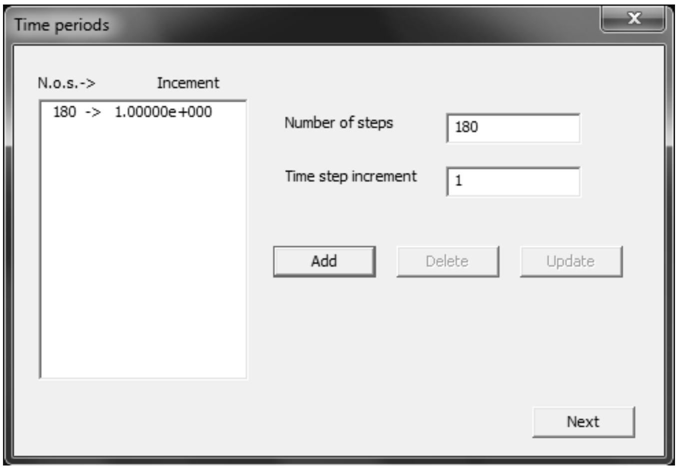

Fig.5 Translator dialog for selecting time periods

Next step is set up of ***Iteration method*** (***Arc length + full Newton***) and data for automatic load stepping (Fig. 6)

Node Number: 47
Direction: 2 (2 represents y direction)
Value: -1 (initial displacement)
AG :2 (coefficient of increase of displacement)
DS: 2 (coefficient of arc length increase)

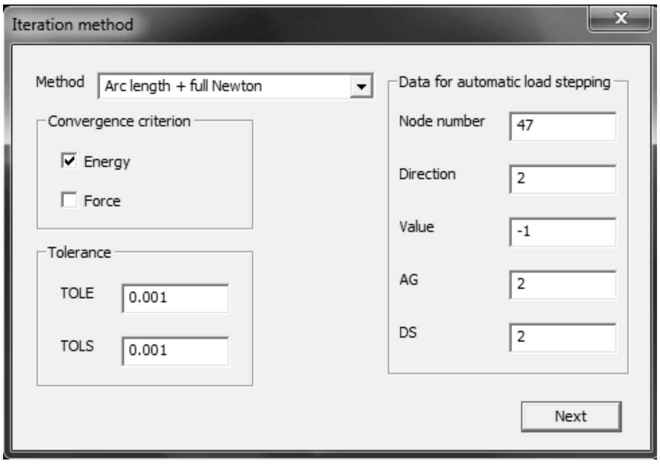

Fig.6 Translator dialog for selecting iteration options and automatic load stepping

After researchers have entered all necessary data, they can start FEM analysis by clicking ***Analyze*** button (Fig. 1). This action starts analysis in R&D solver PAK, and when the analysis is finished users can load analysis results (Fig. 7).

Fig.7 Analysis Complete dialog

When researchers click on ***Load Results*** button (Fig. 7). results are loaded into FEMAP and translator (Fig. 1) is closed. In order to view values of interest, such as stress or displacement, users need to select option from FEMAP Menu *View->Select* [6]. In *View Select* dialog users can select *Deform* and *Contour* as style and click on *Deformed and Contour Data...* button which opens dialog *Select PostProcessing Data* in which users need to select what data to display. For example, selection of *Solid Von Mises Stress* and click on *OK* button on this and previous dialog gives stress values displayed on deformed shape (Fig. 8).

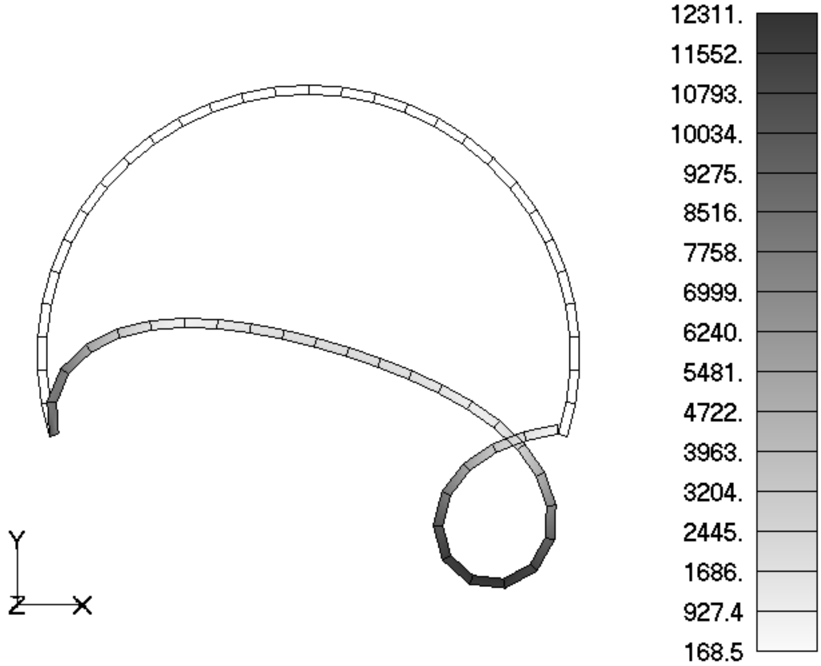

Fig.8 Analysis results: Solid Von Misses Stress

View Select dialog can be used to plot XY charts as well. if users want to export chart data they can use *List->Output->XY Plot* which will write data in specified *.rtf file. From that file data can be copied into Excel. Excel charts showing displacement of the node at which the force acts is shown on Figure 9 and Figure 10.

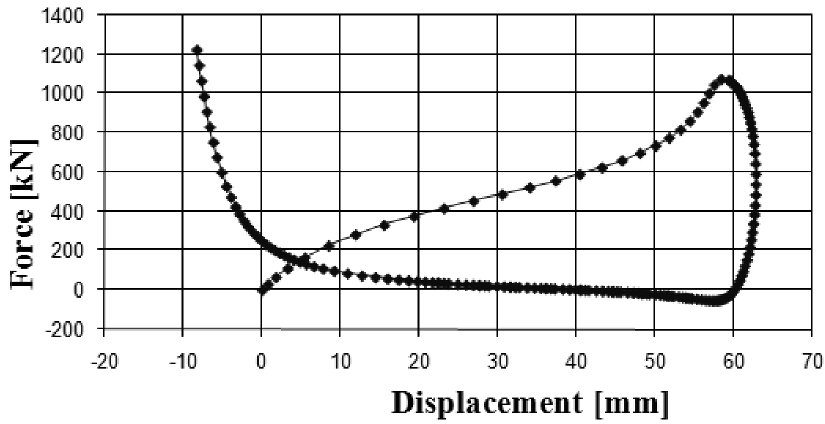

Fig.9 Displacement in X direction of the node at which the force acts

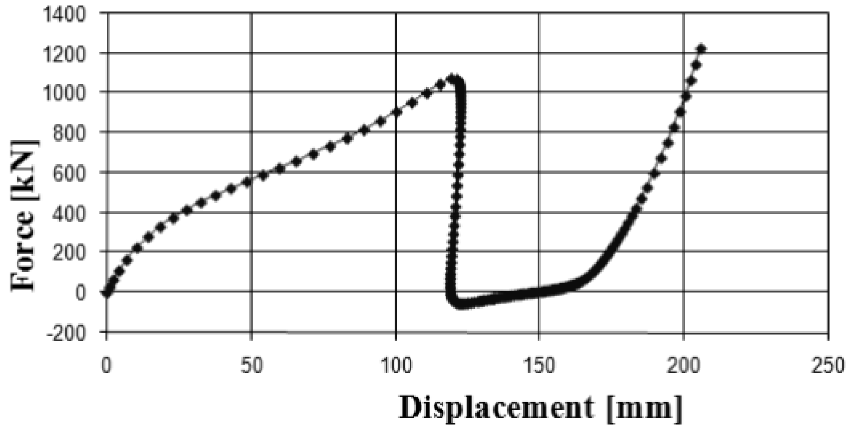

Fig.10 Displacement in Y direction of the node at which the force acts

6. CONCLUSION

R&D FEM solution PAK offers researchers opportunity to work on development of FEM program, to test their new material models, element types or numerical procedures. In this paper we described how we connected pre- and post-processing program FEMAP with PAK. Automatic generation of solver input file as well as automation of entire FEM analysis process is described. Implementation of new translator significantly reduced tedious workload that hurdles researchers in their research giving them more time to do actual research.

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LITERATURE

[1] de Souza Neto, E.A., Perić, D., Owen, D.R.J. (2008). Computational Methods for Plasticity Theory and Applications, John Wiley &Sons,Ltd., United Kingdom
[2] K.J. Bathe, (1995). Finite Element Procedures, Klaus-Jürgen Bathe, U.S.A.
[3] Jensen, D., Pramono. E.,(1998), Method for Teaching Finite Elements Which Combines the Advantages of Commercial Pre- and Postprocessing with Student-Written Software, Computer Applications in Engineering Education, vol. 6 105-114
[4] Holzapfel, G.A., (2000). Nonlinear Solid Mechanics a Continuum Approach for Engineering, John Wiley &Sons,Ltd., United Kingdom
[5] Belytschko, T., Liu, W.K., Moran, B., (2000) Nonlinear Finite Elements for Continua and Structures, John Wiley &Sons., United Kingdom
[6] FEMAP 10.0 Online Help, Distributed with FEMAP installation
[7] Kojić M., Slavković R., Živković M. and Grujović N., (1996). PAK-finite element program for linear and nonlinear structural analysis and heat transfer, Faculty of Mechanical Engineering, University of Kragujevac, Yugoslavia
[8] Živković M., (2006). Nonlinear Structure Analysis , Faculty of Mechanical Engineering, University of Kragujevac, Serbia, (in Serbian)