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AxisVM® - EDUCATIONAL PURPOSE OF ONE CAA SOFTWARE

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1. INTRODUCTION

Due to numerical efficiency and simple software implementation finite element method (FEM) has become a major method of a structural analysis and numerical modeling of structural behavior.

Structural modelling - creation of an idealized and simplified representation of structural behaviour is an essential step in structural analysis and design. Errors and inadequacies in modelling may cause serious design defects and dificulties. Numerical modelling is a mathematical realization of selected structural modelling concept.

The software implementation quality decides how much the advantages of FEM in modeling would be expressed. Thus, as the key one, is imposed the problem of choice of the CAA software.

AxisVM® is a Microsoft Windows® based high productivity CAA FEM software tool for civil engineers. Due to it's extensive analysis capabilities (designed for use by civil engineers), AxisVM has proved to be successful applied in design of projects ranging from large complex structures to small and simple buildings.

Performs static, vibration and buckling analysis of 3D bar, membrane, plate, and shell structures. Enables use of an unlimited number of nodes and unlimited number of elements that can freely be combined in a model.

2. DICRETIZATION - MODELING OF STRUCTURAL TOPOLOGY: AxisVM® PRE-PROCESSOR

AxisVM (Visual Modeling) provides a leading edge user interface with multiwindow model creation and display. Each graphics window has its independent settings. During any command it is possible to switch to the graphics window that shows the best view of the model or results of your action. Fig. 1 shows typical AxisVM working enviroment.

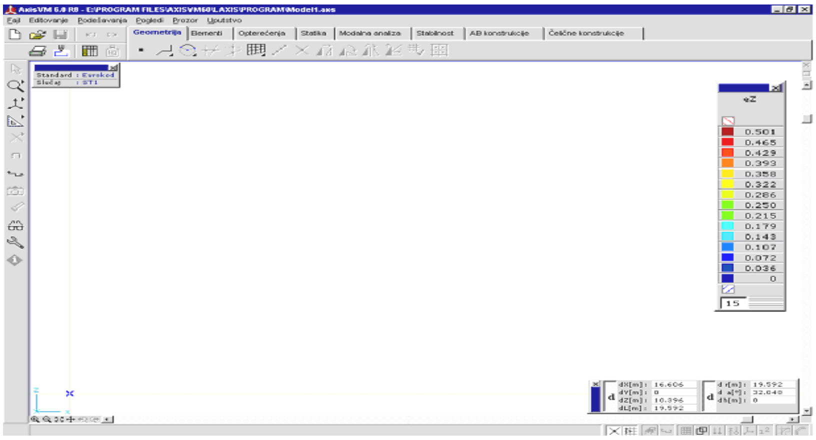

Figure 1. AxisVM working enviroment

AxisVM structure editor enable:

- geometry modeling in 2D or 3D and geometry generation commands (translation, rotation, mirror, copy, move...etc.).
- powerful selection tools (filtered selection available),
- complete set of zoom in/out, fit, pan, undo/redo commands,
- working on parts (allows easy editing of most complex 3D geometries and includes advanced part management),
- wireframe and rendered display (see Fig. 2),

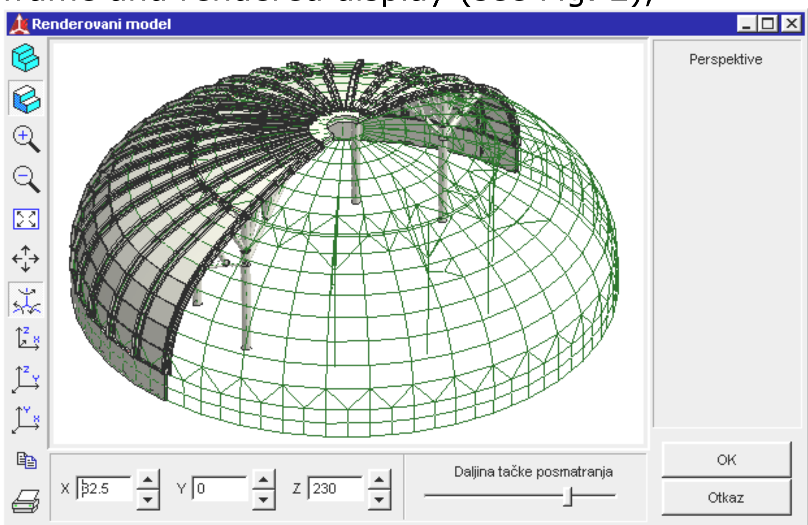

Figure 2. AxisVM Rendered model display example

- section lines for surface element results display,
- search for entities by type and index,
- automatic duplication check feature,
- graphically created joints, members, finite elements, properties, constraints, releases and loading,
- pre-loaded steel cross-section libraries loaded with most of the available European and U.S. shapes and creation of custom libraries,
- integrated fully graphical cross-section editor for complex shapes (all cross-sectional properties are automatically calculated based on the graphical input of the section's shape),

Consequences of unsuitable discretization can be easy observed even by unsufficiently experienced CAA software users without high level of knowledge from theory of structures, i.e. FEM application. On contrary, problems that can appear due to errors in numerical modeling (approximatization), are much more complex.

3. APPROXIMATION - NUMERICAL MODELING OF STRUCTURAL BEHAVIOUR: AxisVM® PROCESSOR

AxisVM implements an object-oriented finite element architecture that inherits more reliability than the classical systems. Provides a variety of finite elements for modeling frames and/or surface structures, special elements for modeling boundary conditions and connections and elements with nonlinear capabilities:

- line elements: truss, beam, rib (the truss and the cubic beam element are the most widely used finite elements for bar, beam, or column modeling,
- surface elements (Fig 3.): membrane, plate, shell (the surface elements are isoparametric flat quadrilateral (8/9-node) or triangular (6-node) elements,

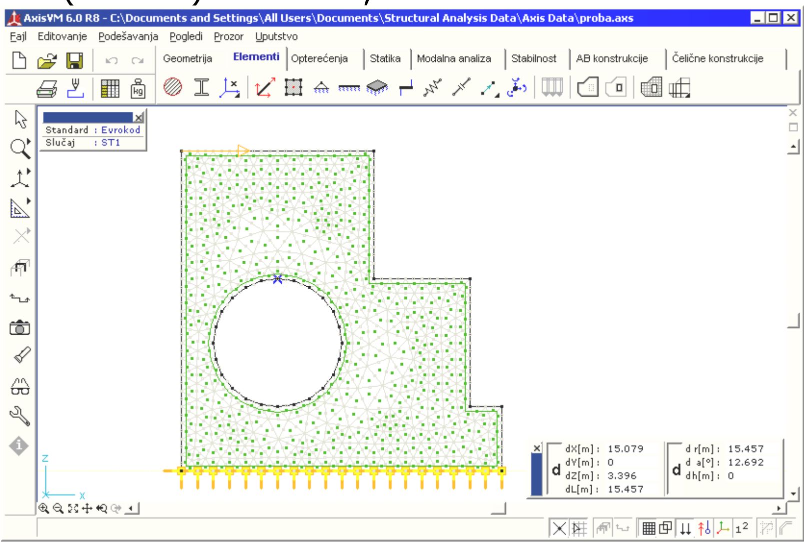

Figure 3. AxisVM Shell FE modeling example

- Winkler type elastic supports for line and surface elements can model elastic foundation support conditions,
- joint support elements with arbitrary orientation and stiffness,
- gap elements for contact modeling can model point-to-point contact conditions,
- spring elements for linear/nonlinear support or semi-rigid connection modeling can account for linear or nonlinear elastic support or connection behavior,
- link elements for connection modeling can be node-to-node (connect nodes to nodes), or line-to line (connect ribs, ribs to surfaces, or surface sides) and

- Rigid elements can model rigid parts of your structures without assigning large stiffness values to an element and the element can have any number of nodes.

Various loads can be applied on the nodes and the finite elements. Up to 99 load cases can be applied on a model and any number of load combinations can be generated from these load cases. The load cases can be classified in load groups for automatic critical internal force calculations.

AxisVM performs most of the analyses typical in the practical design of civil engineering structures: linear static analysis, buckling analysis (Fig. 4), nonlinear static analysis: displacement/force controlled incremental iterative solution, free vibration analysis: eigen-shape and -frequency computation (Fig. 5) and earthquake analysis - response spectrum analysis - Eurocode 8, ISA (Italian), STAS (Romanian) and MSz (Hungarian).

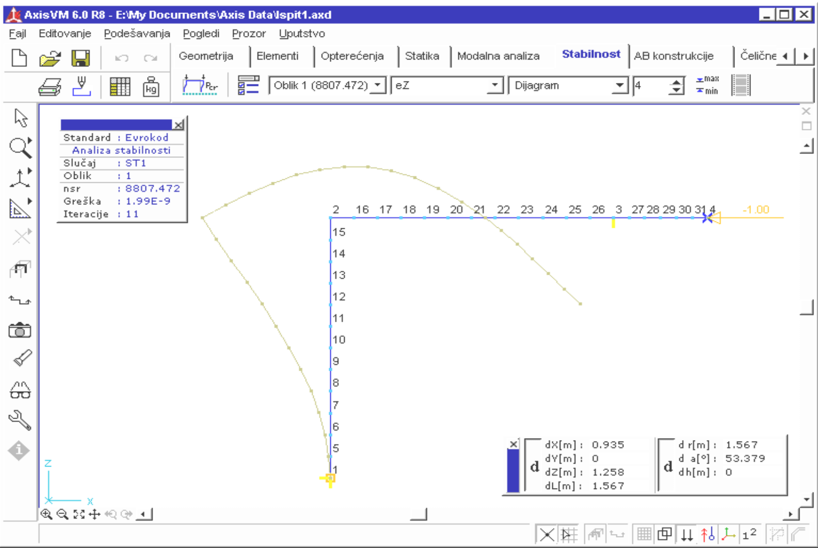

Figure 4. Example of AxisVM linear buckling analysis

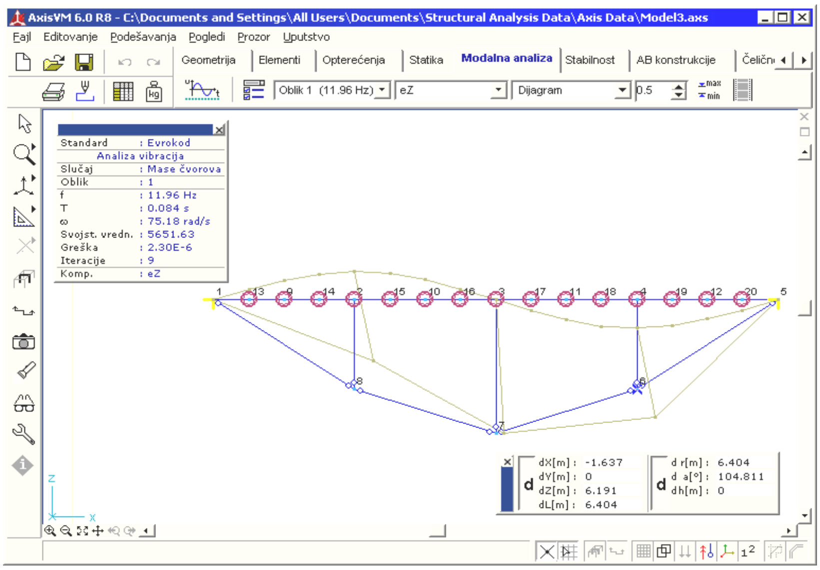

Figure 5. AxisVM Free vibration analysis example

4. ANALYSIS RESULTS DISPLAY AND DESIGN ACCORDING SPECIFIC NATIONAL CODE: AxisVm® POST-PROCESSOR

Civil engineers use AxisVM for the analysis of structures with confidence that their final engineering product will meet their country specific design codes. The ease of results exporting allows each user to connect AxisVM to almost every locally produced and national code compliant design and detailing software.

Options are various: diagram analys results display (Fig. 6), isoline and isosurface analys results display (Fig. 7), analys results display for section lines and for structure parts, reinforced concrete design, steel design, integrated Report Generator to create savable report templates for every needed construction partner.

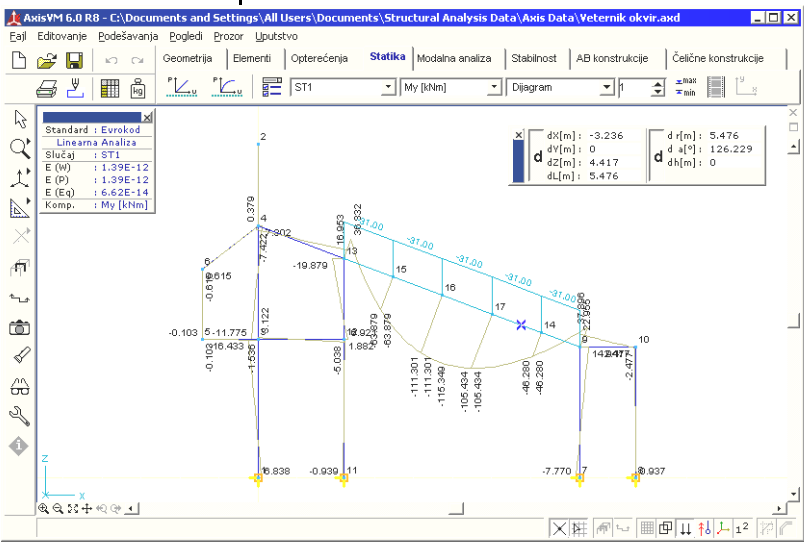

Figure 6. Diagram display of analysis results

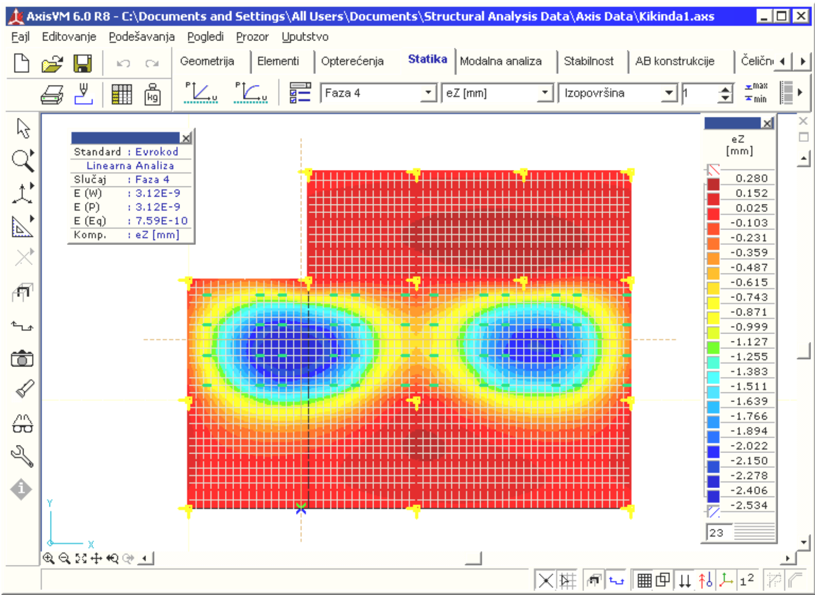

Figure 7. Isosurface display of analysis results

5. FINAL REMARKS AND CONCLUSIONS

The software implementation quality decides how much the advantages of FEM in modeling would be expressed. Thus, as the key one, is imposed the problem of choice of the CAA software.

Development, distribution and application of CAA software is the area where the professional competence is essential, but provided that rather high education in the field of computer sciences is also possessed. It is, this, clear that the team who develop text-processor, for example, must have included sufficiently educated programmers. On the other hand, the team working on CAA program development must be extremely competent in engineering-structural issues, and optimally good in programming sense. Very similar relations apply when distribution and, particularly, program application are in question. Engineers for engineers develop AxisVM.

In connection to this, arises the question of educational concept. In addition to high knowledge in the primary profession (structural analysis and design) also is needed knowledge providing that the software being developed has good performances (numerical mathematics, software design and programming), to have a good quality in software distribution (computer technology knowledge at the advanced user level, sense for marketing and public relations) and for competent use of the software (numerical mathematics and use of computer technology at the advanced user level). The author considers that each and every technically oriented faculty should make possible this concept in education.

Education and, especially, testing of the knowledge in the primary profession should be adapted, first of all, to need of complete understanding of the essence of structures. Gaining of the "encyclopedia like" knowledge by studying of many methods for analysis possibly provide wide education and contributes to the technical culture, but it takes away attention and energy and ruins enthusiasm of students. Such knowledge is insufficiently used and are not necessary if in the analysis the CAA software is applied in competent manner. All this reasons cause introduction of AxisVM software in program of subject "Modeling and Computer Aided structural Analysis".

6. REFERENCES

[1.] AxisVM® Version 7.0 - User's manual, Translation in Serbian by D. Kovačević & L. Rajsli, hiCAD, Novi Sad, 2003.

[2.] D. Kovačević & R. Folić: FEM Implementation in Civil Engineering Numerical Modeling and Structural Analysis Software, 24th Congres of Theoretical and Applied Mechanics, Belgrade, 2003.

[3.] R.D. Cook: Finite Element Modeling for Stress Analysis, John Wiley & Sons, Inc., 1995.