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ARHITECTURE OF FINITE ELEMENTS IN ANALYSES STRESS OF TOOTH MECHANICAL STRUCTURES

Džafer Kudumovic , Lana Kudumović, Indira Buljubašić
University of Tuzla

ABSTRACT
As far as the surface soil mining is concerned at the surface coalmines, there are usually large quantities of the excavated material comparing to the quantities of mineral resources, which causes significant exploitation costs.The important fact here is the number of delays because of the frazzle of the cutting element (tooth) of the dredge shovel. The very fact proves that the previous approaches in solving this issue did not meet the basic efficiency requirements of the dredge exploitation. In this study, only some of the parameters that affect the cutting body strength have been discussed.

1. INTRODUCTION
The process of excavation and scrapping basically comes to the process of cutting, and therefore in every specific case we have different width of cutting tool. Even today, as it is already emphasized, at the analysis of process we mainly lean on the principles and thesis determined for the metal cutting, and therefore some of the authors based their interpretations of this process on the theories determined for the cutting of metal.
The examinations carried out in this direction show that when the chisel impresses into the brittle material it leads to destruction similar to destructions described in the drilling process. In the beginning there are elastic deformations, then the plastic ones and at the end the crumbling of the material under the chisel. The depth of the crumbled zone depends on the force of impression.
By the end of the last century it comes to the development of several new methods based on the numeric analysis designated for more quality solution of the issue, and there is also elastic-plastic analysis and the mechanics of brittleness, which is significant for selection of the materials for cutting bodies of rotor dredge operating wheel.

2. THE ROTOR DREDGE SHOVELS
By the analysis of force we are able to define the adequate shape of geometry of cutting bodies at the shovel of rotor dredge (shovel tooth), with the intention of increase of the dredge work (bigger capacity, less consumption of the electricity, more effective working hours, less duration of delay because of replacement or regeneration of the shovel tooth).
As a subject of the study, the elements which directly come in grasp with the massifs, the shovels with the shape of cutting body as on the Figure 1. are in use, with the specific knives that can be:
- the knives (cutting edges of the shovel) for light, actually the soils that can be easily cut,
- the knives with angular teeth for medium-heavy soils which still provide good cutting,
- and the knives with teeth for heavy, cohesive soils and solid massifs.

The cutting angle of knife in tangential direction of 7˚ and side angle of 12˚.
For cutting body strength analysis, it is very important to know the working area, actually its geomechanical parameters and also the shape of cutting organ at the shovel of the dredge. In the very same analysis in using the Methods of Finite Elements (MFE) these parameters are the main in the structure regarding the analysis what can be seen from the balanced condition of 3D model.

2.1. Discretization of domain and selection of type of element

The method of finite elements is based on physical discretization of the observed domain. For example, the grid structure is being discretized on line elements the rods. The plate can be divided on surface elements with the shape of triangle or rectangle, figure1. The base for the analysis of construction represents the sub-domain, the part of domain (structure) which is called the finite element.

Since the number of finite elements for one problem is unconditionally big, there is a task of creation of model which approximates the best an appropriate adjacent problem. Selection of the best discrete model depends on intuition, engineering practice and understanding the essence of the discussed issue. The creator of model evaluates the accuracy of desired equation results by his own and according to that he makes the specific decisions and steps. The first step in the structural analysis, actually in the search for stress (pressure) and deformations is discretization of (model) domain. Selection of elements which are used in MFE analysis depends on the issue that has to be solved and on desired accuracy of results.

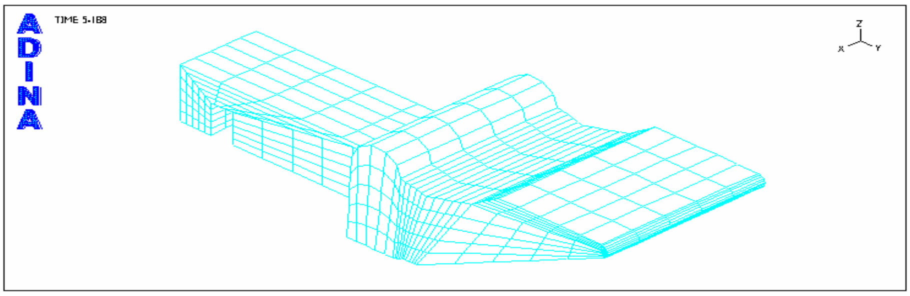

Figure 1. Discretization of domain on the finite elements

The first thing that we must pay attention on is the fact that the problem is one, two or three dimensional. Some of the elements in discretization of problem are shown in the Figure1.

2.2. Mathematical defining of the analysis probe

During the study we used the algorithm Figure 1 for the implementation of the finite elements method. We disregarded some segments but they can be incorporated in one entirety. For solving of this problem we used the balanced condition of 3D model of equations 1-1.

The system of 3D body balance equation comes to the solution of equation:

$$K : U = R \qquad (1\text{-}1)$$

Where is: **K** – stiffness matrix

U – vector

R – load vector

The matrix **K** includes the shape and the characteristics of geometry and material given by the equation 1-2:

$$\mathbf{K} = \int_v BT \cdot C \cdot B \cdot dv \qquad (1\text{-}2)$$

Where is: B – geometry matrix

C – material matrix

The matrix B is a dependant of the shape geometry (body). The solution of equations of the finite elements method can be based on several settings and depending on which partial differential equation we are solving.

2.3. Algorithm of used procedure in stress analysis

The scheme of use of FEA includes three stages which are shown in the Figure 2.:

- pre-processor,
- processor,
- post -processor.

In the phase of pre-processing, the geometry, physical and mechanical characteristics, edge conditions and the load are given, and we define the analysis process (linear or non-linear, static or dynamic, nonlinearity of geometry and similar).

The processor itself solves the given task (equation) on the base of instructions of the finite elements program by the obtained algorithm. Postprocessor is the procedure of the equation results analysis, it gives the overview of output values, types and ways of graphic presentation. At the same time in this phase we analyze the obtained results and their quantitative evaluation.
Postprocessor consists of graphic and numeric presentation of the results obtained in the phase of calculation. In this phase we also perform the raw analyze of the obtained results. The algorithm of the process program, which is used for solving the mechanics of solid bodies, can be shown by the diagram. The process algorithm by itself for the solid body analysis can be shown by the diagram in the Figure 2. By the finite elements method, we have studied here the contact of two bodies and the contact surfaces, the point lines are shown in the Figure 1. The models consist of 4238 knots, 3120 elements and 6 contact surfaces which are generated.

2.4. The model of material

The cutting body material has been studied as the nonlinear – elastic body with the physical and mechanical characteristics of the deformability parameters:
- Young's Module of elasticity $E = 21000$ [M Pa] and
- Poisson's coefficient $v = 0.3$
- The volume mass $\rho = 7600$ [kg/m^3]

The model of labor force in the Figure1. has been studied as the elastic – plastic body with Mohr – Colombo fracture condition $t = \sigma \cdot \tan \varphi + c$
where is :t – sliding stress, φ – inner abrasion angle, σ – normal stress
The calculation of the excavation resistance has been conducted by the program ADINA R&D.

3. THE RESULTS OF STUDY

From the process through the ADINA program it is evident that the stresses in coal are from 5,67-86,67 kN/cm²; in sand from 0,9-11,70 kN/cm²; and in clay from 3-39 kN/cm² for the cutting body. and Table 1..

Table 1.Stress disposition for the cutting body 1 and 2

Stress disposition [$\cdot 10^{-2}$ kPa]		
Working environment material	**Cutting body 1**	**Cutting body 2**
Clay	3 - 39	4,50 – 58,50
Coal	5,67 – 86,67	30 – 390
Sand	0,9 – 11,70	0,667 – 8,667

4. CONCLUSION

The analysis of cutting body strength of the rotor dredge shovel has been conducted by the numeric method (MKE), actually by the method of finite elements.
In this paper presented by the method of finite elements on discretization of domain ,whos is presentation in analyses stress in work of rotor dredgres .
In this case the phase of knife penetration into the ground to the level of fraction has been analyzed.
We have encompassed the area of the origin of elastic and plastic deformations.
Experienced-based data according to the field and laboratory examinations
Among the data obtained by measuring and the data obtained by the numeric procedure, the discrepancies are within the tolerable limits and the results meet the technical normatives and standards.

5. REFERENCES

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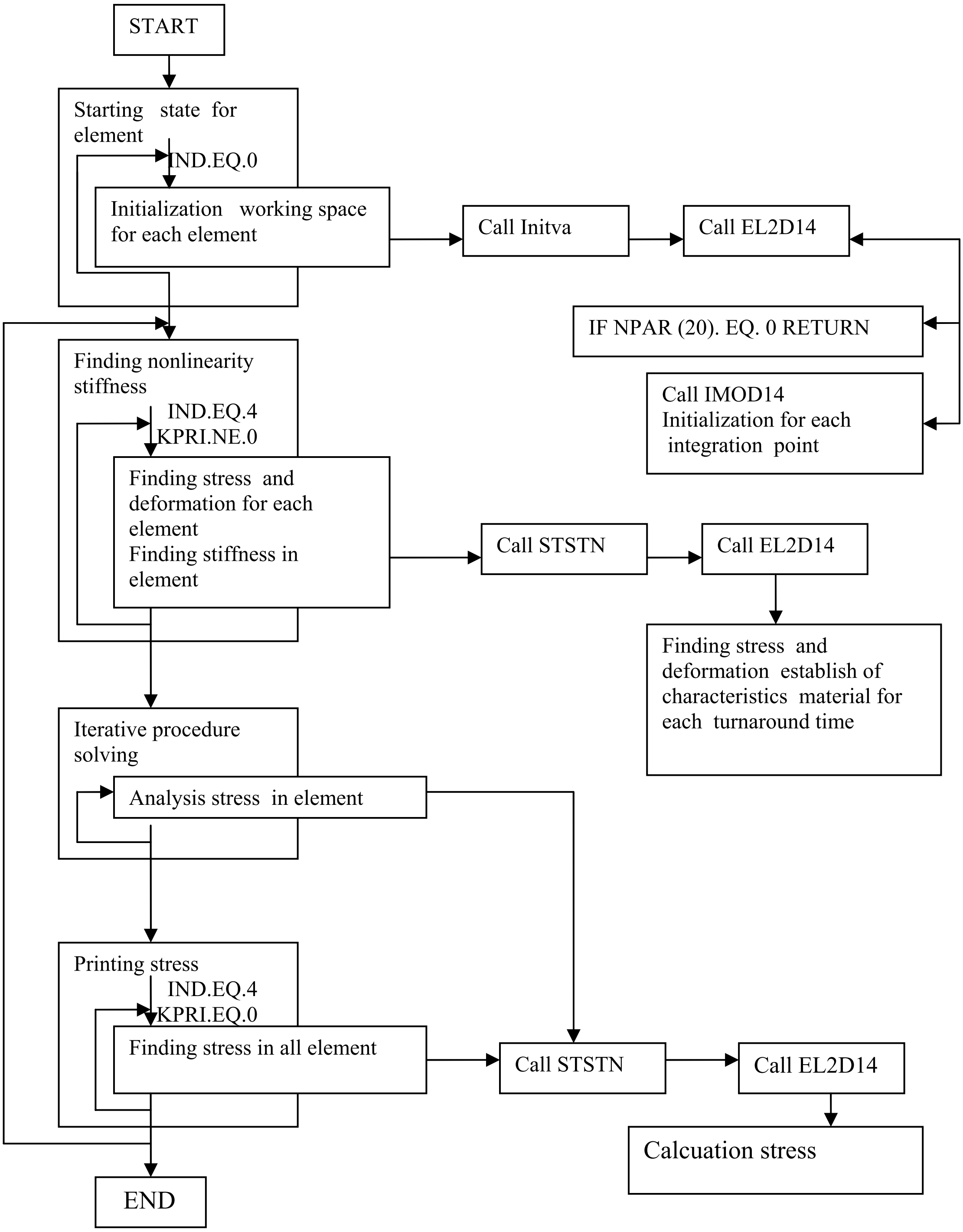

Figure 2. Algorithm – the scheme of FEA calculation (scheme of the FEA processor procedure – the extract from the ADINA algorithm)