Analele Universităţii din Craiova, seria Agricultură – Montanologie – Cadastru (Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series) Vol. 51/2/2021

STRUCTURAL STATIC ANALYSIS OF THE CURVED STILT BY FEM USING THE ELCUT PROGRAM

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Keywords: the ELCUT program, stilt, finite elements

ABSTRACT

The paper presents a study of the distribution of stresses and strains in the curved stilt of the plough-body, using the ELCUT analysis program by the finite element method. In its public version, the program allows the static structural analysis in three stages of precision. However, there are some limitations on the number of nodes for the discretized structure, depending on its complexity (250 to 500 nodes).

INTRODUCTION

The ELCUT program used for the structural structural analysis of the curved stilt allows the study with a high degree of precision of the deformation of the curved stilt, under the action of the resistant force resulting in the plowing process, and allows the study of the distribution of nodal displacements, distribution of main stresses and the equivalent stresses.

MATERIAL AND METHOD

General considerations on the use of the ELCUT program

ELCUT is a finite element analysis program. Its version destined for public use allows the study of electro and magneto-static, thermostatic and thermodynamic, but especially the distribution of forces (stresses) and deformations (strains) in flat plates, of constant thickness (Bao et al, 2019; Sorohan Şt., 1996).

The study consists in discretizing the studied object, which means "breaking" into small "pieces" named finite elements, which are considered non-deformable. This leads to a network structure, the keywords being node (vertex) and edge (edge) (Biriş S.Şt., 2007; Zhang Z., 2020).

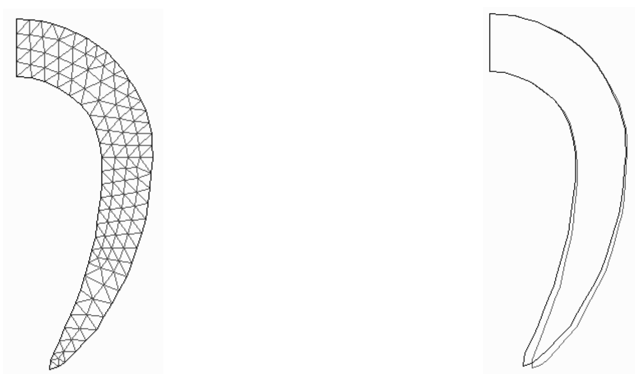
The denser or rarer mode of discretization is decisive both for the accuracy and finesse of the results and for the working speed of the computer. The higher the number of nodes, the better the resolution, but the longer the computation time (Biriş S.Şt., 1999; Blumenfeld M.,1995; Căproiu et al., 1982, Jianfei et al, 2021).

The ELCUT program allows the study with the Finite Element Method, and there are limits on the complexity of the studied object (250 to 500 nodes, depending on the complexity of the studied problem) (Liu W., 2019; Blumenfeld M.,1992).

RESULTS AND DISCUSSIONS

This section presents the results of the study using the ELCUT program to analyze the state of stress and the distribution of strains for the curved stilt of the plough-body, which is required in the working process by a maximum strength from the soil F=10 kN. The stilt is made of steel, for which the longitudinal modulus of elasticity is $E_X=E_Y=E_Z=2.1 \cdot 10^{11}$ N/m^2, Poisson's ratio is $\nu_{XY}=\nu_{XZ}= \nu_{YZ}= 0.3$, the transverse modulus of elasticity is GXY = G_{XY}=8,0769³$10^{10}$ N/m^2, and the thickness of the curved stilt is t=50 mm (Cârdei et al, 2012; Vlăduţ et al, 2012; Ungureanu et al, 2016).

The discretization of the curved stilt is shown in Figure 1 a), for which 134 nodes were used. The deformed curved stilt is presented in Figure 1 b).



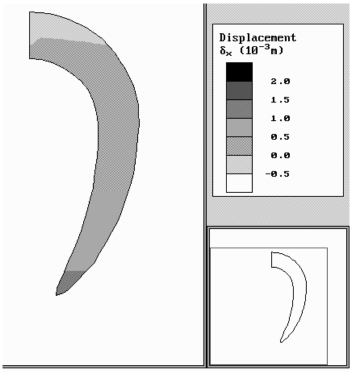
a) *b)*

Fig. 1. a) Discretization of the stilt, b) Deformed

The distribution of nodal displacements in the horizontal direction is shown in Figure 2 a), and the distribution of nodal displacements in the vertical direction is shown in Figure 2 b). Figure 3 presents the distribution of total nodal displacements calculated with the following equation:

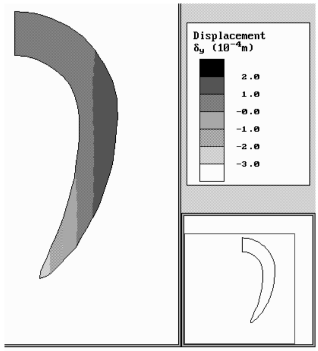
$$\delta = \sqrt{\delta_x^2 + \delta_y^2} \tag{1}$$

Figure 3 shows the direction, size and direction of the total nodal displacement vectors.



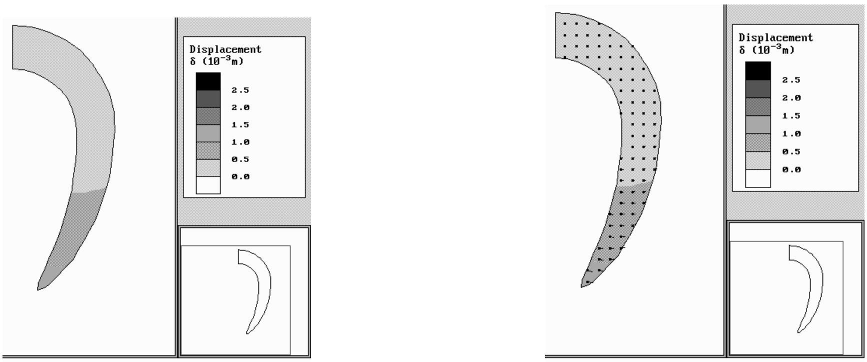
a)

Fig. 2 a) Nodal displacements in horizontal direction



b)

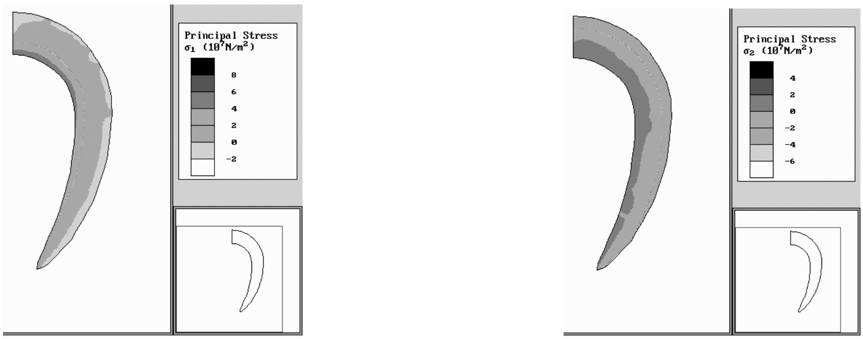
Fig. 2 b) Nodal displacements in vertical direction



a) ***b)***

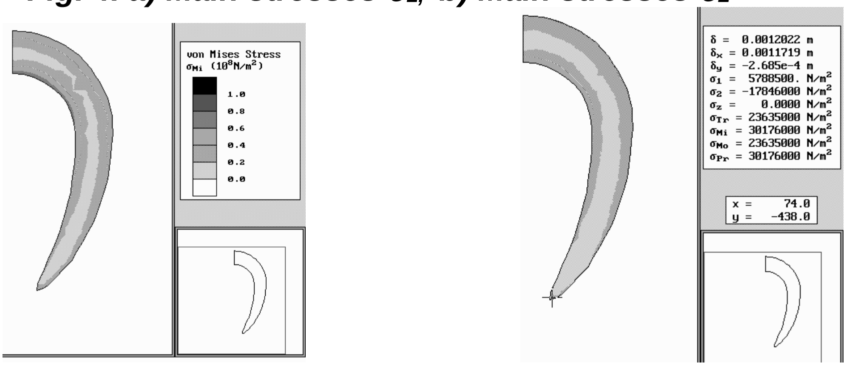
Fig. 3. a) Total nodal displacements, b) Displacement vectors

The distribution of the main stresses σ_1 and σ_2 can be observed in Figure 4 a), respectively in Figure 4 b). Figure 5 a) shows the equivalent stresses in the curved stilt, calculated according to the Von Mises criterion, which allows the identification of areas where these equivalent stresses are minimum (median area) and maximum (peripheral area). For the point found in the area of application of the resistant force which loads the the curved stilt, the complete set of results is also presented (Figure 5 b), respectively: total displacement δ, displacement in the horizontal direction δ_X, displacement in the vertical direction δ_Z, main stress σ_1, main stress σ_2, the stress according to the z direction σ_Z, the equivalent stress according to the Tresca criterion σ_{Tr}, the equivalent stress according to the Von Mises criterion σ_{Mi}, the equivalent stress according to the Mohr-Coulomb criterion σ_{Mo} and the equivalent stress according to the Drucker-Prager criterion σ_{Pr}.



a) b)

Fig. 4. a) Main stresses σ_1, b) Main stresses σ_2



a) b)

Fig. 5. a) von Mises equivalent stresses, b) The set of results for the point in the Figure

Figure 6 shows the graphical variation of nodal displacements along the entire contour of the curved stilt. Figure 7 shows the variation of equivalent stresses on the entire contour of the stilt, and

Figure 8 shows the variation of tangential stresses on the entire contour of the stilt.

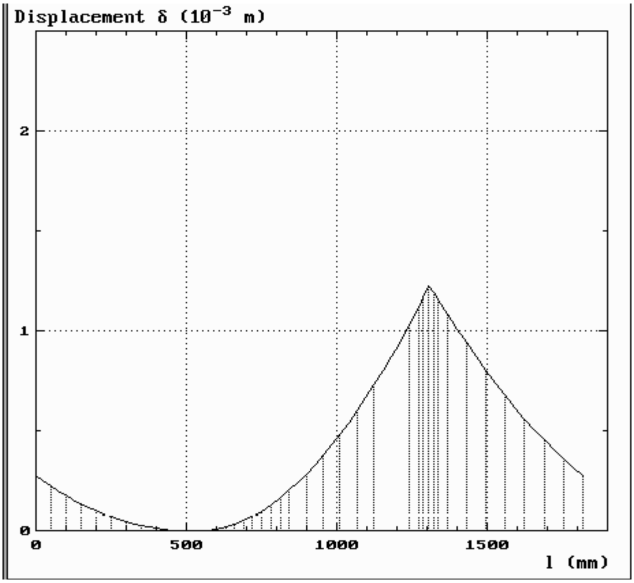


Fig. 6. Variation of nodal displacements along the entire contour of the stilt

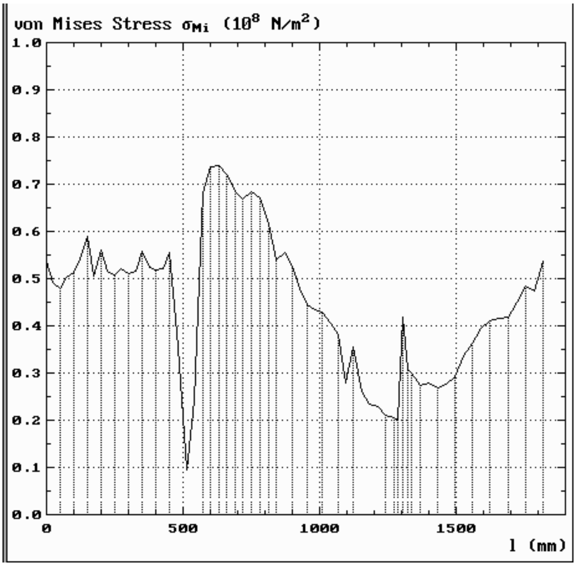


Fig. 7. Variation of equivalent stresses along the entire contour of the stilt

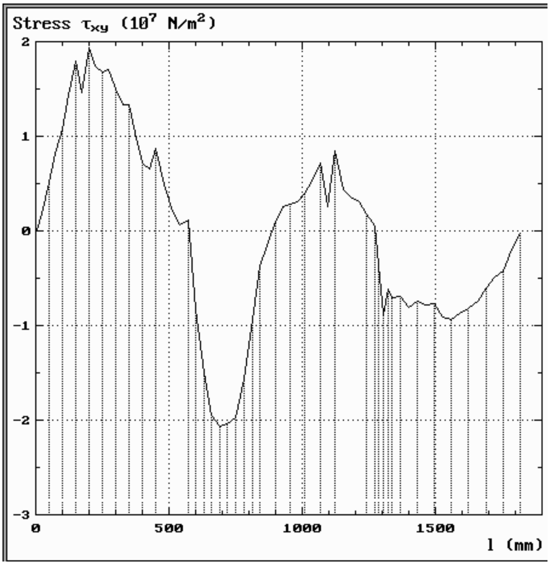


Fig. 8. Variation of tangential stresses τ_{XY} on the entire contour of the stilt

CONCLUSIONS

1. The structural static analysis of the curved stilt of the plough-body can be easily and faithfully performed using the ELCUT study program using the Finite Element Method.
2. It can be seen that the tip of the curved stilt supports the largest displacements (Figures 2 and 5).
3. This model allows the analysis of the stress distribution from any point on the curved stilt (Figure 4).
4. The ELCUT program allows the calculation of the complete set of results for any point of the curved stilt (Figure 5).
5. The ELCUT program allows the graphical plotting of the variation of the nodal displacements, of the equivalent stresses and of the tangential stresses on the whole contour of the curved stilt or in certain areas of interest (Figures 6, 7, 8).
6. The highest stresses are found in the peripheral area of the curved stilt, and the lowest in the area of the deformed medium fiber, which determines, for optimization, the decrease of the stilt thickness in the middle area, respectively the increase of the stilt thickness at the peripheries.

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