ANALYSIS BY THE FINITE ELEMENT METHOD OF THE TENSIONS AND DEFORMATIONS PRODUCED IN THE MECHANIZED SUPPORT BEAMS

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Abstract: This paper presents the analysis by the finite element method of the tensions and deformations produced in the mechanized support beams. The finite element method allows the analysis of physical phenomena that can be described with the help of mathematical models made up of systems of differential equations with initial and boundary conditions. From the results obtained in this paper, it was observed that the asymmetries with the greatest influence are those with respect to the vertical-longitudinal plane of the mechanized support

Keywords: finite element, deformation, CAD, analysis, beams

1. INTRODUCTION

The finite element method allows the analysis of physical phenomena that can be described with the help of mathematical models made up of systems of differential equations with initial and boundary conditions. The deformation phenomena of solid bodies, the determination of thermal and electromagnetic fields, the analysis of velocity and pressure fields in a fluid, constitute only a part of the application potential of the finite element numerical modeling method

The most important concepts of the Finite Element Method are the following: structure, calculation model, discretization, node, finite element. Also, the finite elements can be classified according to various criteria, namely: the type of analysis, the functional role, the geometric shape, the number of nodes, the number of degrees of freedom of each node, the degree of the interpolation polynomial, the characteristics of the material.

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The fundamental concept with which this method operates is that of approximation by discretization. The bodies, considered as continuous media, are decomposed into a finite number of geometric elements (parts of the body), with the same physical and functional properties as those of the initial body. Using these finite elements, the differential analytical model is transformed into a numerical model, which can be entered and solved on a computer.

The finite element analysis method is a numerical method used to solve engineering and mathematical physics problems.

The method subdivides a complex problem into simpler, smaller parts, which are called finite elements. The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem.

This paper determines the tension and deformations achieved in the mechanized beams inside the coal mines using the finite element method.

2. METHODOLOGY AND RESULTS

For start, the determination of the most stressed areas and the size of the maximum stresses and deformations, in the situations of symmetrical-asymmetrical three-dimensional loading of the beam that is part of the mechanized support, was aimed at.

The first figure shows the geometry of the beam sub-assembly in the composition of mechanized support. Because the support has symmetry geometric, but not mechanical in the case of loading spatial, must be fully discretized.

We decided to choose from the element library of the ANSYS program the element type SHELL 63 which has 4 nodes located in the plane of the median surface, each with 6 degrees of freedom in every knot. The geometry, node location and coordinate system for this element type are shown in figure no. 2.

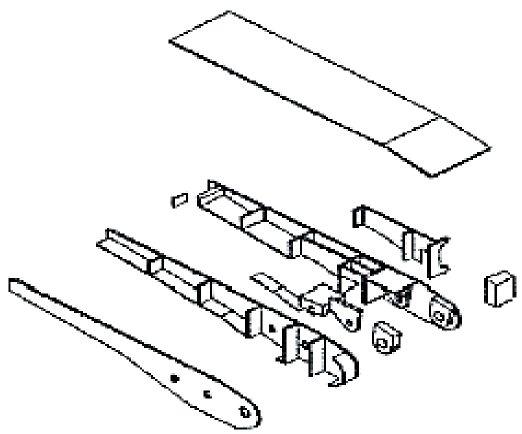

Fig.1 The geometry of the beam sub-assembly in the composition mechanized support

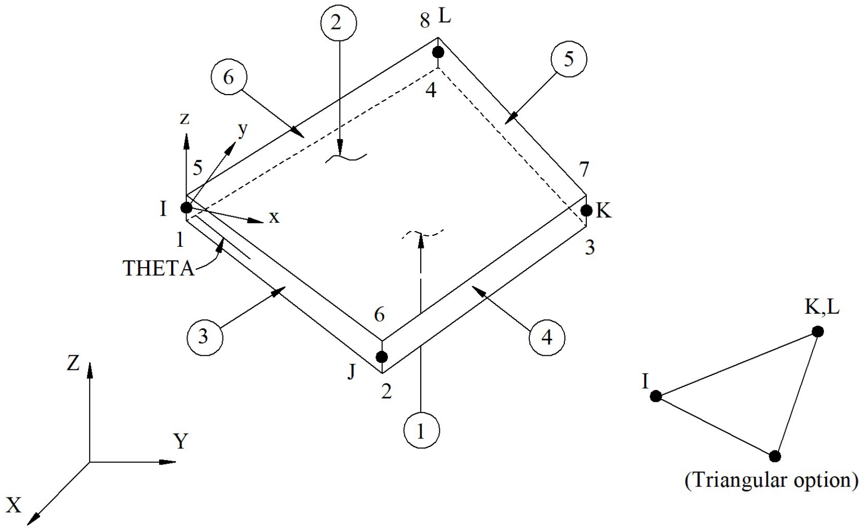

Fig.2 The geometry, node location and coordinate system for the element type

The third figure presents the result of the discretization process of the beam subassembly what does it do part of the support mechanized in elements finished. The finite element model contains 30561 elements and 39416 knots. At first glance, maybe the number of finite elements even large and the dimensions of the elements finite small but behind of repeated runs, we wanted to get as close as possible to the exact

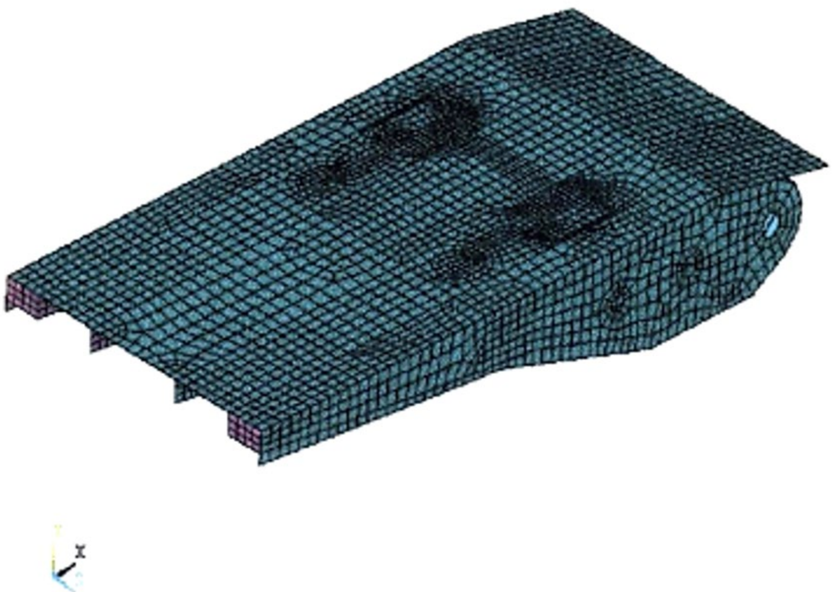

Fig.3 The result of the discretization process of the beam subassembly

It was found that for this structure increasing the number of finite elements over value mentioned does not bring any improvement significant of the convergence that to justify the additional computational effort. Physical characteristics of of the materials are $E=2.1x10^5$ N/mm^2, $\mu=0.3$.

The support of the structure was modeled by imposed displacements and rotations (Ux=Uy=Uz=0; ROTx=ROTy=ROTZz=0) nodes on the transverse areas of hydraulic cylinder pistons (fig. 4), as well as through forced travel (Ux=Uy=Uz=0) of the joint nodes.

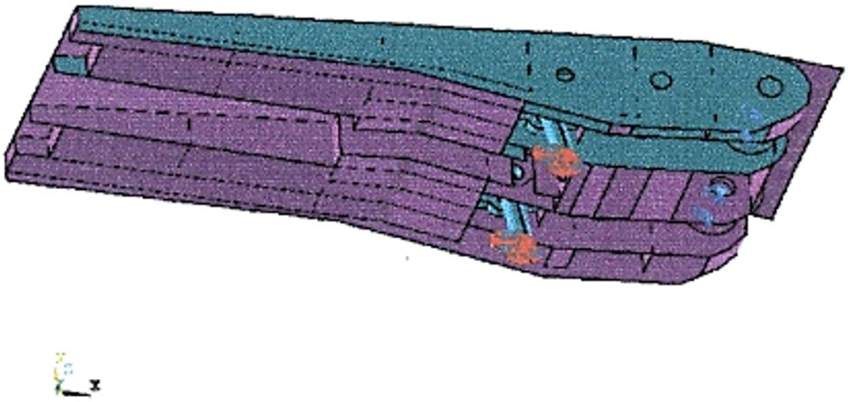

Fig.4 The transverse areas of hydraulic cylinder pistons

For loading the beam split the beam-rock interaction surface into 50 approximately equal parts (10 along the beam, X-axis and 5 in width, Z axis), pressure distribution on each side being equal to a nodal force. Nodal forces (50 forces) used for asymmetric charge (fig.5) are presented in table 1, and those used for charging symmetrical (fig.6), in table 2.

Table no.1 **Nodal forces for asymmetric charges (N***)*

12559.95	14234.61	15909.27	17583.93	19258.59	0933.25	22607.91	24282.57	25957.23	27631.89
13676.39	15351.05	17025.71	18700.37	20375.03	2049.69	23724.35	25399.01	27073.67	28748.33
14792.83	16467.49	18142.15	19816.81	21491.47	3166.13	24840.79	26515.45	28190.11	29864.77
15909.27	17583.93	19258.59	20933.25	22607.91	4282.57	25957.23	27631.89	29306.55	30981.21
17025.71	18700.37	20375.03	22049.69	23724.35	5399.01	27073.67	28748.33	30422.99	32097.65

Table no.2 **Nodal forces for symmetric charges (N)**

14792.83	16467.49	18142.15	19816.81	21491.47	23166.13	24840.79	26515.45	28190.11	29864.77

It should be mentioned that to compare the results obtained, an equivalence was made asymmetrical loading with symmetrical loading beam-shield so that the resultant of the forces applied in the nodes have the same magnitude.

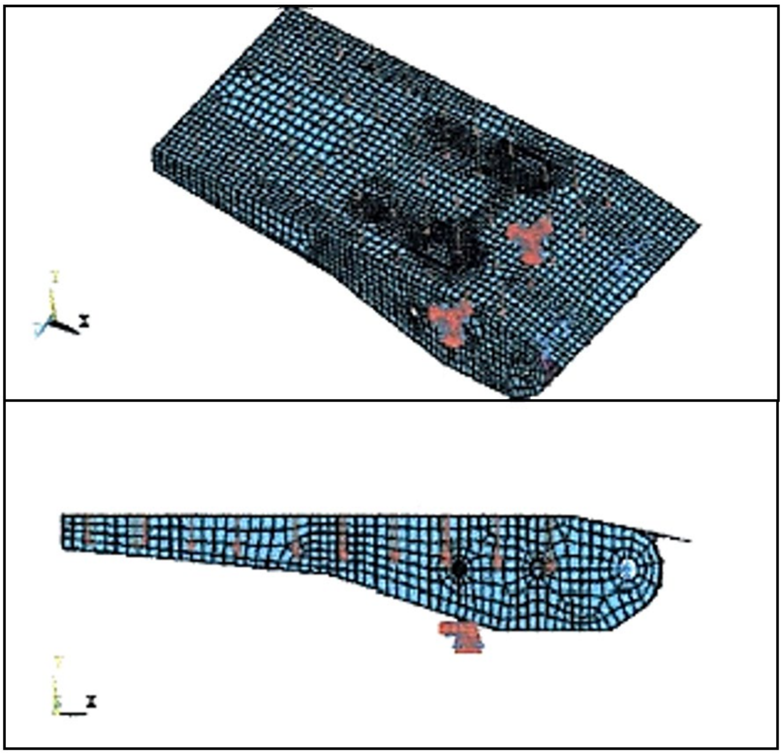

Fig.5 The asymmetric charge

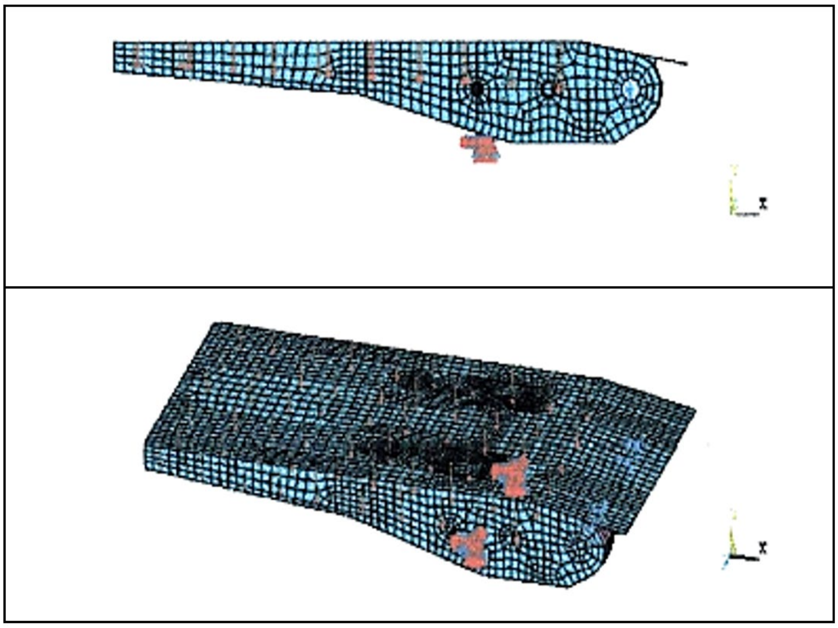

Fig.6 The nodal forces used in the symmetrical charge.

The calculation method can be:

1. For asymmetric loading, the following was adopted: p = 0,2 MPa; K_1 = 1,5; K_2=2,5; a= 2260 mm; b = 1235 mm.The result of distributed loading, in this case, is:

$$P = \frac{1}{2}(p_1 + p_2)a \cdot b = \frac{1}{2}(k_1 + k_2)a \cdot b \cdot p = \frac{1}{2}(1.5 + 2.5)2260 \cdot 1235 \cdot 2.5 = 11165 kN \quad (1)$$

2. For the symmetric loading, it was done as follows:
   - the condition was set that the two resultants were equal:

$$P_0 = \frac{P_0 \cdot (1+k) \cdot b}{2} \cdot a = P \rightarrow P_0 \cdot (1+k) = \frac{2 \cdot P}{a \cdot b} \quad (2)$$

- it was imposed that the position on the x-axis of the force resultants in the 2 cases be the same:

$$x_c = \frac{(-p+3p_1+4p_2) \cdot a}{6 \cdot (p_1+p_2)} = \frac{(-1+3k_1+4k_2) \cdot a}{6 \cdot (k_1+k_2)} \quad (3)$$

$$x_{Co} = \frac{(1+2 \cdot k) \cdot a}{3 \cdot (1+k)} \quad (4)$$

$$x_c = x_{Co} = \frac{1+2 \cdot k}{1+k} = \frac{-1+3 \cdot k_1+4 \cdot k_2}{2 \cdot (k_1+k_2)} \quad (5)$$

As a result of these calculations for the symmetrical loading, it was obtained: P_0=0,25 and k =2,2.

Figure 7 present the equivalent stresses in MPa for symmetrical and asymmetrical loading. For symmetrical loading, the maximum equivalent stress resulted in front of the bearing of the main hydraulic cylinders, under the beam (δ = 204,4 MPa). For asymmetric loading, the equivalent stress has the maximum in the same area (δ = 25,3 MPa).

Figure 8 and figure 9 show the displacements in mm for symmetrical loading respectively asymmetric. In the case of both loads, the maximum displacement resulted at the top of the beam.

From those presented previously for the asymmetric spatial loading, tensions resulted equivalent to about 20% higher than in the case of equivalent symmetrical loading. It is found that in both cases, the area in front of the pillars, for both types of loads, reach maximum values. The area behind the main hydraulic cylinders holds up very well at charging.

For symmetrical loading, the stresses in the area of the hinge bolts with the shield are smaller than in the case of asymmetric loading. The upper plate of the beam, in both cases, is less stressed.

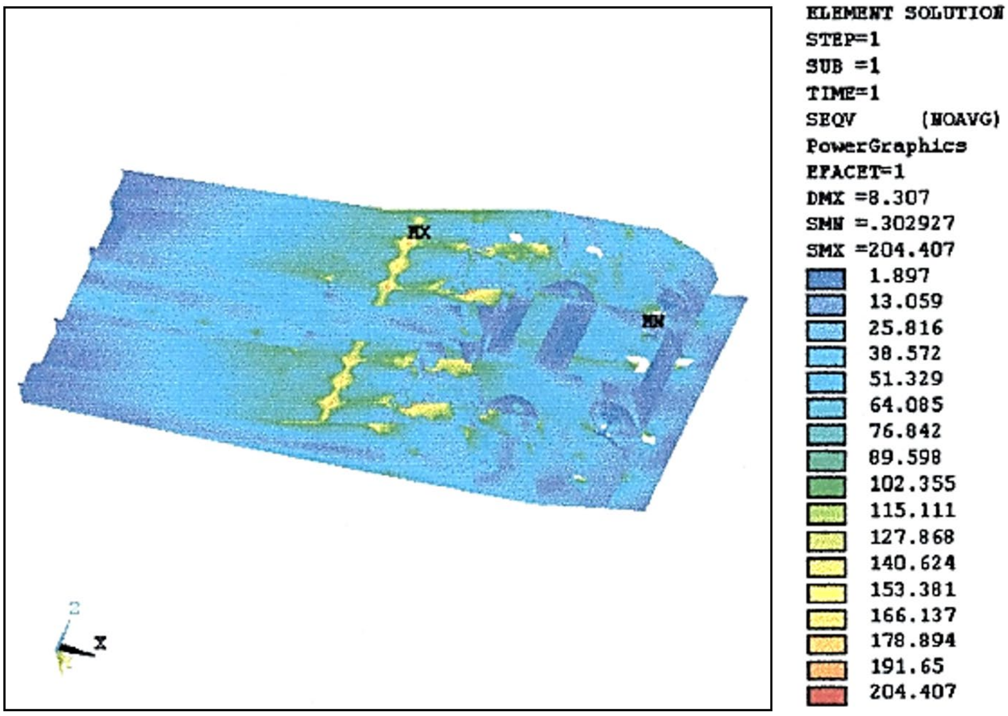

Fig. 7. The equivalent stresses in MPa for symmetrical and asymmetrical loading

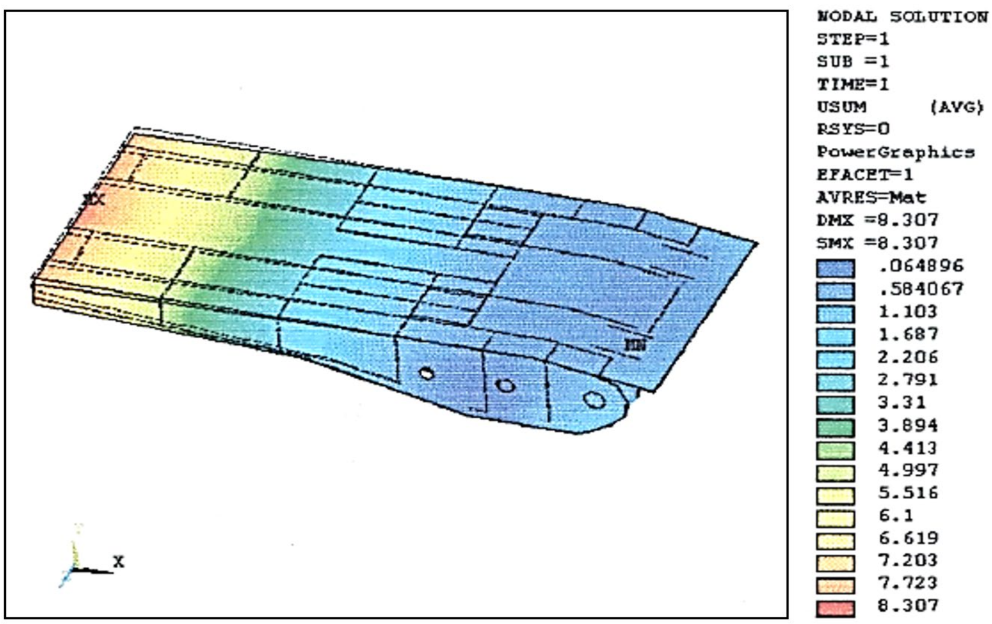

Fig. 8. The displacements in mm for symmetrical loading

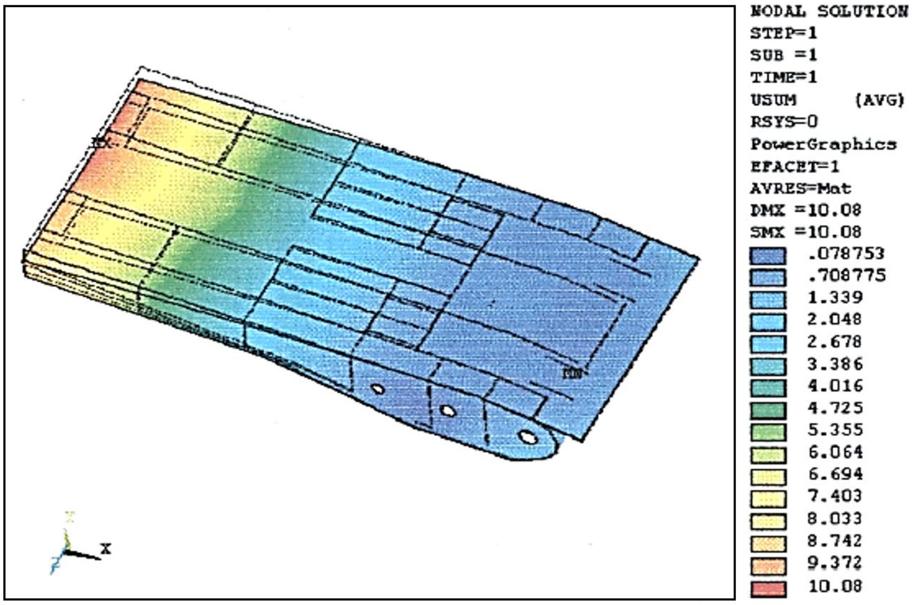

Fig.9. The displacements in mm for asymmetrical loading

3. CONCLUSIONS

From those previously presented for the spatial asymmetric loading, the equivalent voltages were about 20% higher than in the case of the equivalent symmetrical loading. For the beam, it is found that in both cases the area in front of the columns, for both types of loading, reaches maximum values. The area behind the main hydraulic cylinders withstands the load very well. From the results obtained in this chapter, it was observed that the asymmetries with the greatest influence are those with respect to the vertical-longitudinal plane of the mechanized support.

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