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Analysis of design characteristics of a V-type support using an advanced engineering environment

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Abstract. Modern mining support, for the entire period of their use, is the important part of the mining complex, which includes all the devices in the excavation during his normal use. Therefore, during the design of the support, it is an important task to choose the shape and to select the dimensions of a support as well as its strength characteristics. According to the rules, the design process of a support must take into account, inter alia, the type and the dimensions of the expected means of transport, the number and size of pipelines, and the type of additional equipment used excavation area. The support design must ensure the functionality of the excavation process and job security, while maintaining the economic viability of the entire project. Among others it should ensure the selection of a support for specific natural conditions. It is also important to take into consideration the economic characteristics of the project. The article presents an algorithm of integrative approach and its formalized description in the form of integration the areas of different construction characteristics optimization of a V-type mining support. The paper includes the example of its application for developing the construction of this support. In the paper is also described the results of the characteristics analysis and changings that were introduced afterwards. The support models are prepared in the computer environment of the CAD class (Siemens NX PLM). Also the analyses were conducted in this design, graphical environment.

1. Introduction

The production of hard coal exceeds currently 7 billion tones. Coal is mined by two methods: surface and underground mining [1]. Poland is the 9-the hard coal producer in the world. This is why the mining industry is an important are of design activities in mining area. In the case of Polish mining industry the basic mining method is the underground one. It is more cost consuming that the surface one. Additionally it is more severe method. The design and operation of mining devices and equipment depends on the geology of the coal deposit. The main mining method, used in Polish mining industry is the longwall one. It involves the full extraction of coal from a section of the seam, or face. It is realized by mechanical shearers. In Poland the coal face vary from 100-200m (the distance on which the whole, assembled longwall complex can operate). The longer is the face the more economic is the mining operation using the longwall complex. The important part of this complex is set of self-advancing, hydraulically-powered supports. They hold up the roof temporarily while coal is mined. The operation of a support is strongly related with the inclination of the hard coal seam. In figure 1 is presented exemplar stratification of hard coal seams.

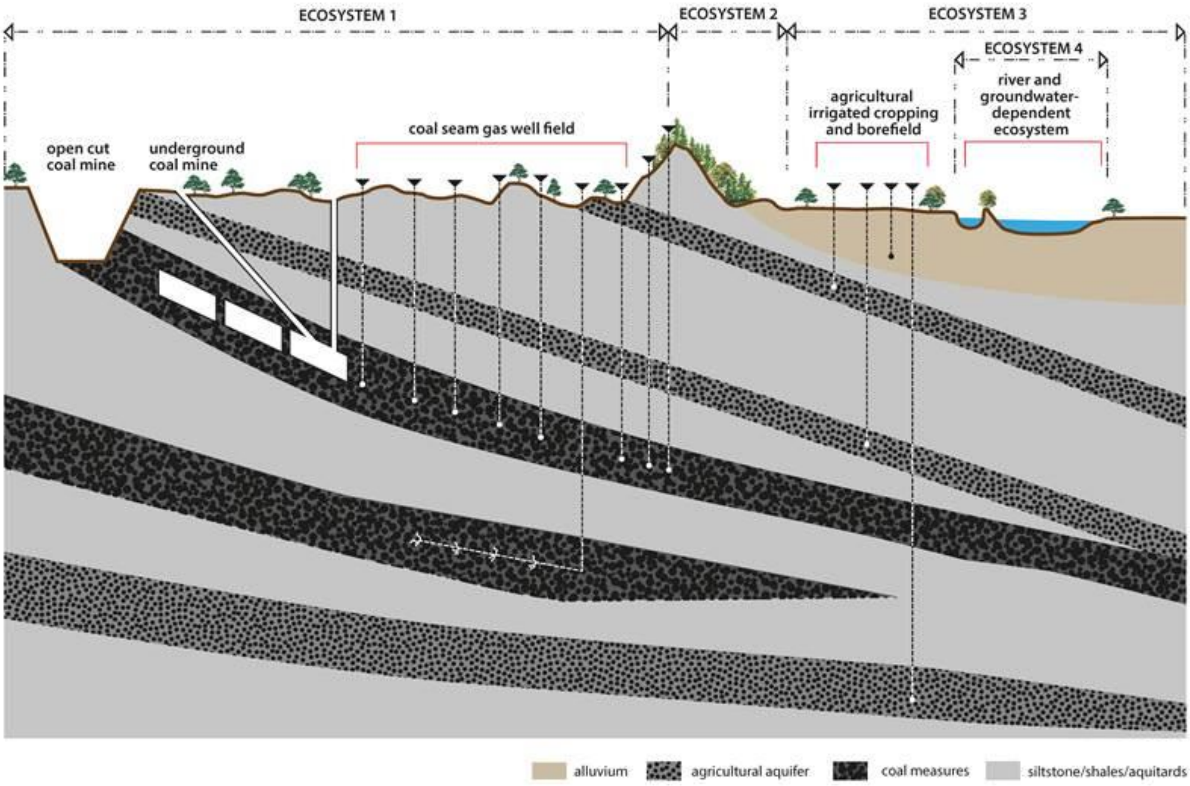

Figure 1. Stratification of hard coal seams [2].

As it was stated the operation conditions of a powered roof support are strictly related with the arrangement of coal strata. This is also the most important factor consider with the design process of the support. In the paper are presented results of FEM analysis of proposed V-type support concerning the strength distribution. The objective of the analysis is to obtain the stress patterns for different direction of rock mass load what is related with different inclination of a hard coal seam.

The proposed virtual model of the V-type support has been elaborated in the advanced design environment of the CAD/CAM class [4-8]. The design approach was based on the integration of elementary design solutions. These elementary solutions are as following: the "material" one, the "drive" one and the "control" one [9, 10].

2. Analyzed roof support design

A typical powered roof support consists of some basic components. To this group one coul includes: a canopy, a caving shield, two foot pieces, a lemniscate mechanism and props. In the proposed design the constructional change has been related with the arrangement of props [3]. The props are placed forming the shape of a letter V. The bottom mounting points are located close one to another, and the spacing of upper mounting points is much large. This is due to an attempt to adjust the direction of props operation to more often skew line of roof rocks load.

The other problem which also should be considered during designing a support is the range of pulling up the support. In figure 2 are presented different stages of the V-type support pulling.

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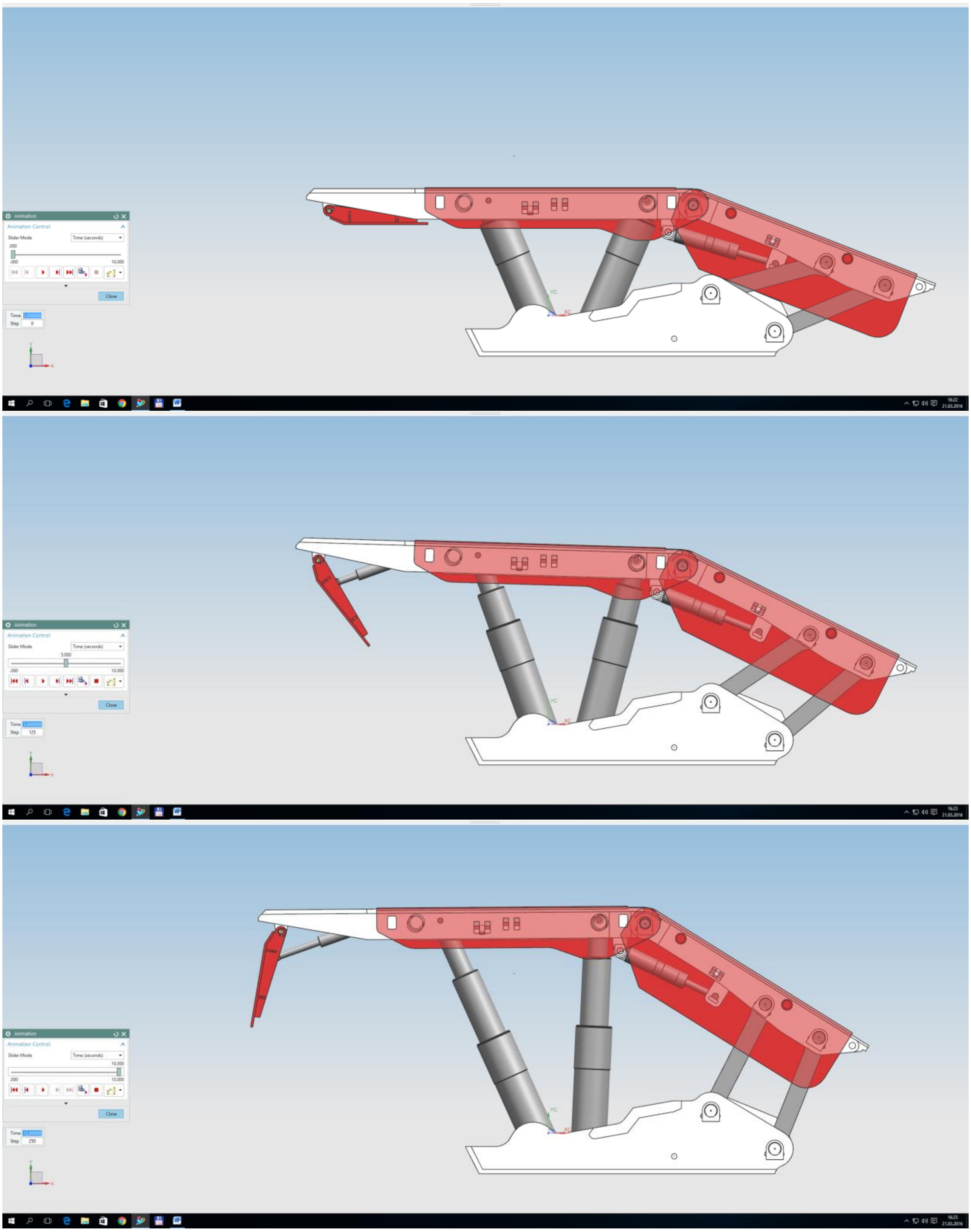

Figure 2. Minimal, medium and maximal pulling up of the V-type support.

As it could be seen the angle of propos supporting the canopy differs and is depended on the range of pulling the support. At the lowest position it is the largest so the support could easier carry the load of skew seams. At the highest position it could easier carry more vertical loads or a rock mass.

3. Conducted analysis for the vertical roof load

The virtual model of the V-type powered roof support, analyzed in the paper, has been initially loaded with a vertical load of a hard coal seam. This load is characteristic for the horizontal seam. The load was modeled as continuous ones, evenly loading the whole canopy, what is presented in figure 3. The pulling up position of the support is the highest because the main objective is to compare it reaction to the load of the skew hard coal seams. In figure 3 and 4 are presented the stresses distribution and its concentration in lemniscate links.

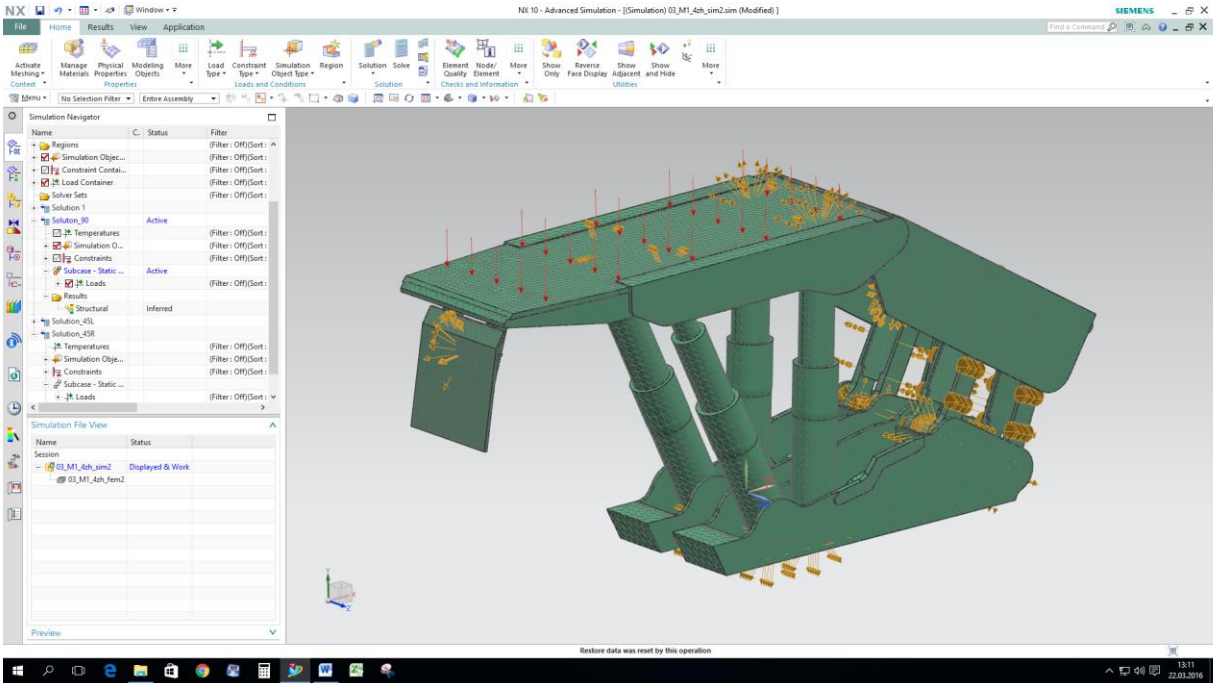

Figure 3. Vertical load of the support model.

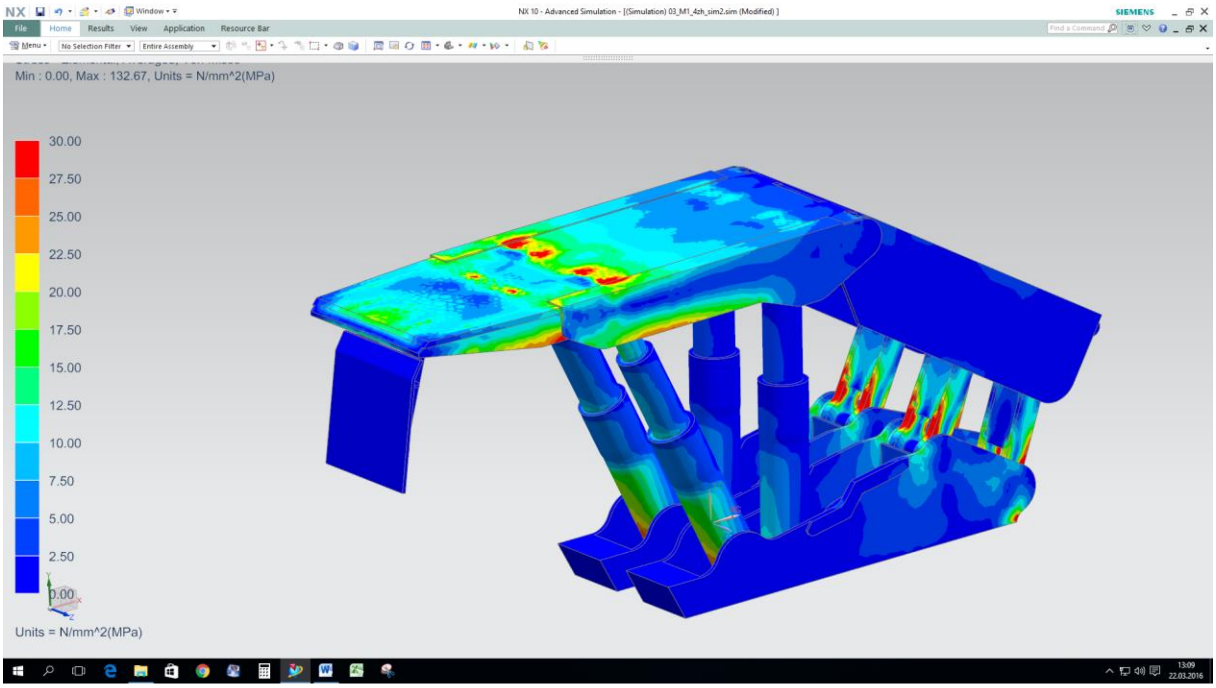

Figure 4. Stresses distribution at the vertical load.

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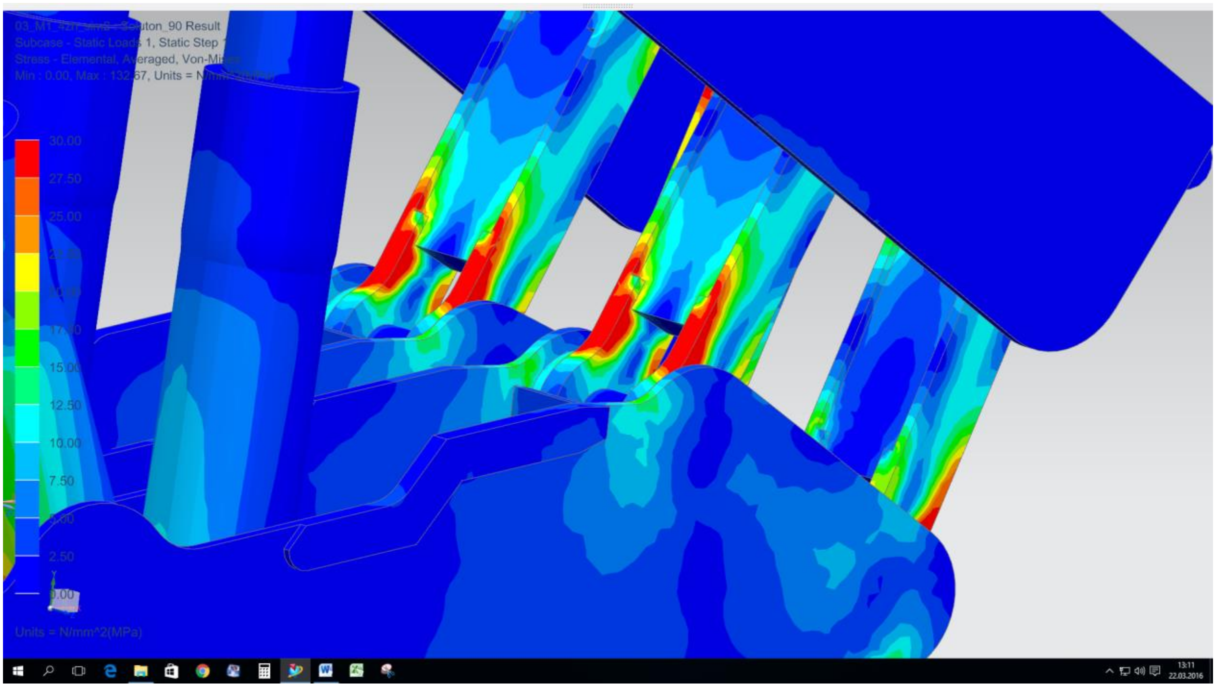

Figure 5. Concentration of stresses in lemniscate links at vertical load.

The FEM analysis shows the concentration of stresses in particularly upper lemniscate links. This result is convergent with mining damage reports concerning powered roof supports.

4. Conducted analysis for the roof load inclination of 45°

The next FEM experiment was conducted at the assumption that the roof mass load is directed towards the front of the analyzed support and at the angle of 45°. In figure 6 is presented the modeled load of the support and in figures 7 and 8 are presented obtained results of stress distribution.

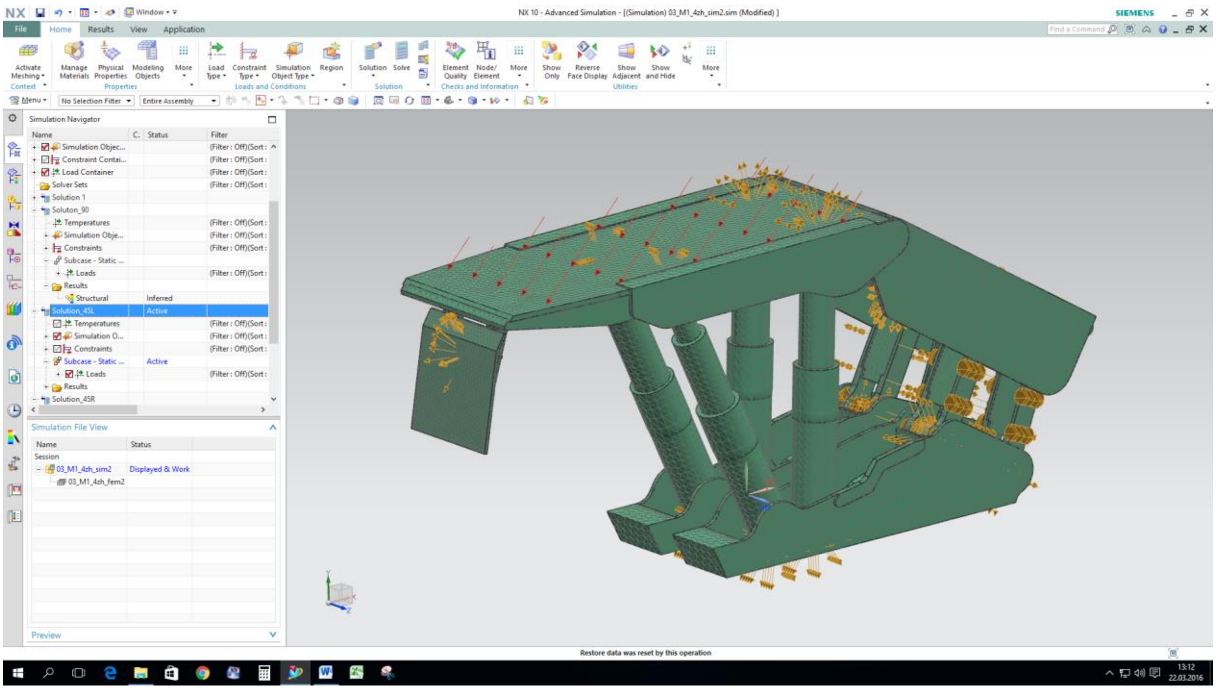

Figure 6. Skew load (45°) of the support model.

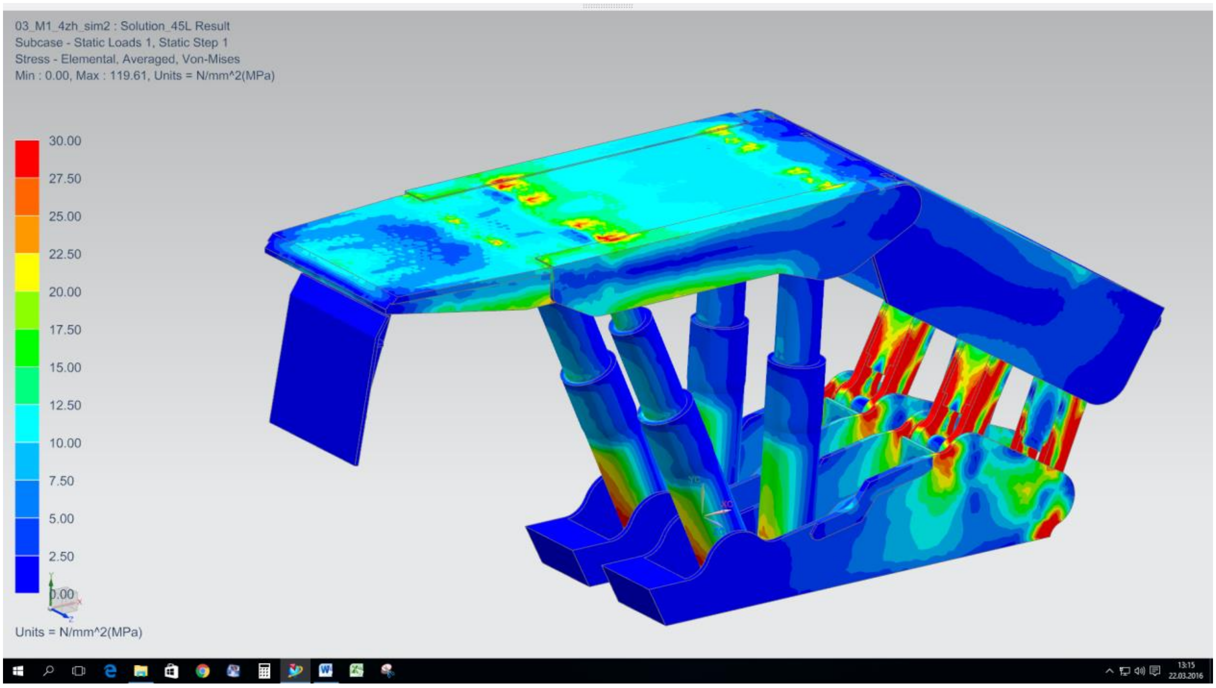

Figure 7. Stresses distribution at the skew load (45°).

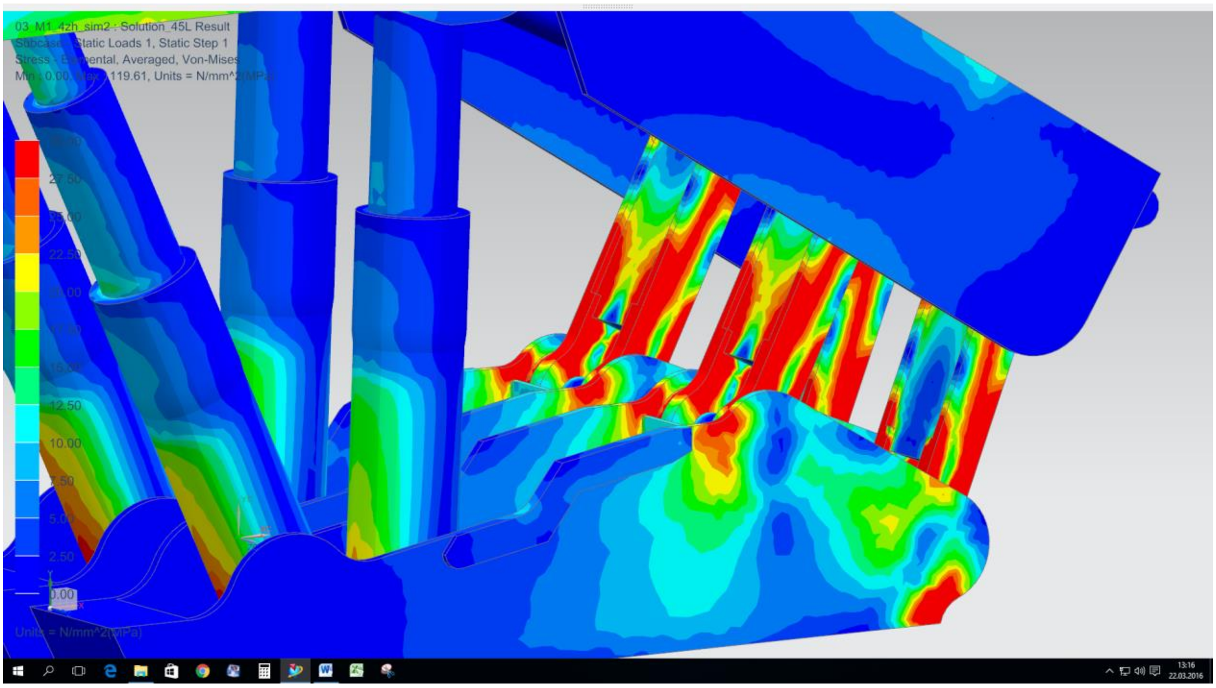

Figure 8. Concentration of stresses in lemniscate links at skew load (45°).

For the analyzed angle of rock mass load (45°) it is observe significant increase of values of stresses in the most effort element (i.e. lemniscate link). It proves that the situation when a support operate in accordance with the direction of wall dip-heading is very unfavorable.

5. Conducted analysis for the roof load inclination of -45°

The last presented analysis concerns the situation when a seam acts on the support canopy from front at the angle of 45°. In accordance of the assumed notation it is the angle of -45°. The load distribution on a virtual model of the support is presented in figure 9. In this figure is also visible the fixing located at the bottom part of foot pieces. It could be mentioned that on this model are also market the joints imposed as boundary conditions for the analysis.

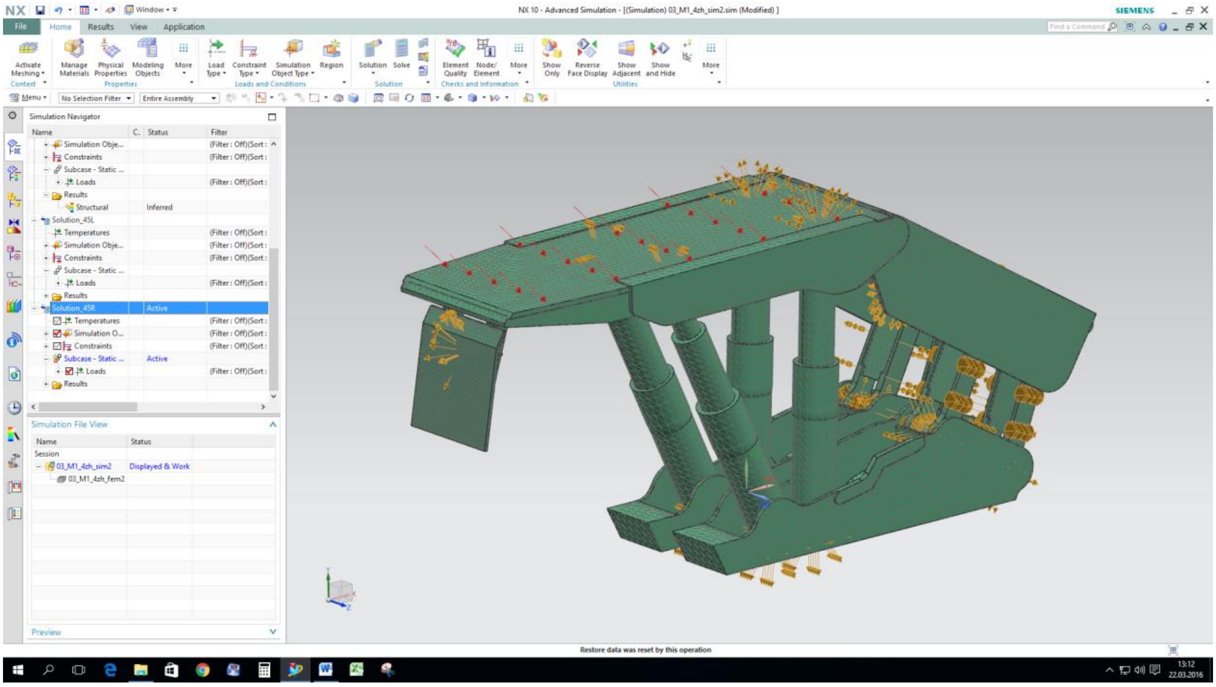

Figure 9. Skew load (-45°) of the support model.

In figure 10 is presented the results of FEM analysis. On this figure is shown the stress concentration at the most loaded element i.e. the upper lemniscate links. It could be observe that the stress composition is less harmful that in the previous case.

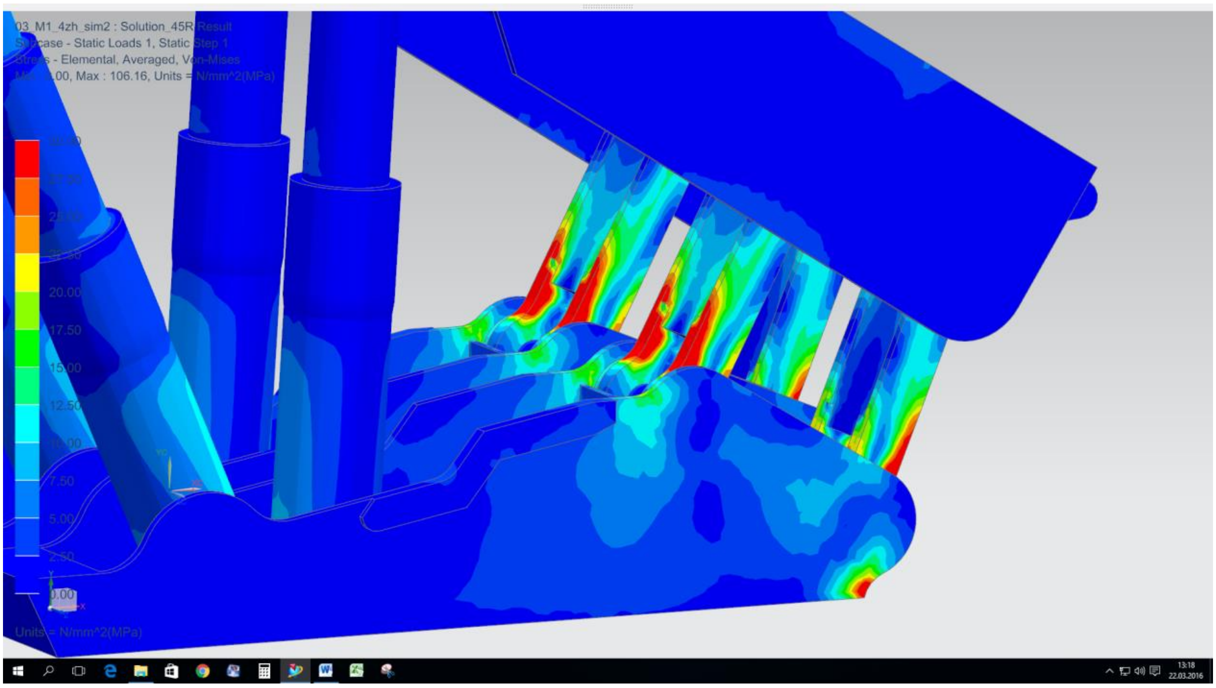

Figure 10. Concentration of stresses in lemniscate links at skew load (-45°).

The analysis of obtained results allows stating that this case is less severe that the previous one (at the angle of 45°). The values of stress in the upper lemniscate links are comparable however the qualitative factors are definitely different. Among others it is visible that in this case (-45°) the maximal values of stresses occur on the upper surface (edge) of upper lemniscate links (like at applying the vertical load).

Taking into account the presented results it is possible to conclude some general proposals concerning the designing such type of a mining support.

6. Conclusions

The results presented in the paper show that depending on the direction of a roof mass load the stress distribution could differ. In particular it considers the load directing obliquely towards the front of the support. In comparison to the vertical load of a roof mass it was observed increasing of stresses in lemniscate links. The high values of stresses were particularly observed for the upper pair of lemniscate links. This allows beginning the works aiming to elaborate the design of the lemniscate mechanism with strengthened joints in the upper pair. It is also possible to conduct investigation considered with improving the technology of these joints production [11,12].

The presented finite elements analysis of the four-props, V-type powered roof support was realized to improve that support design. Secondly it was aimed to improve the stress pattern resulting from the different loads characteristic for different stratification of hard coal seams.

7. References

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