Stability of an Underground Limestone Mine

René Haemers (rhaemers@gmail.com), Frank Broekkamp, drs. Helger van Halewijn
Fontys University of Applied Physics, Eindhoven, The Netherlands

Introduction: The limestone mines in South-Limburg are not equally stable, and can be dangerous in case of a collapse. With COMSOL 4.3a a stability assessment has been made of a cave system and dangerous levels can be traced.

Figure 1. An instable limestone mine

Computational Methods: The structural mechanics module in COMSOL 4.3a has been used to compute the stress and displacement of the limestone caused by the excavation of the mine. This is done by two study steps. Study step 1 generates a solution for the stresses without the excavated tunnels.
Study step 2 starts with the solutions in step 1, but without the domain of the tunnels. In this way the displacements are solely the result of the excavation of the mine.
The model consists of 6.212.371 and 5.493.701 DOF for step 1 and step 2. The solution time was about 2 hours.

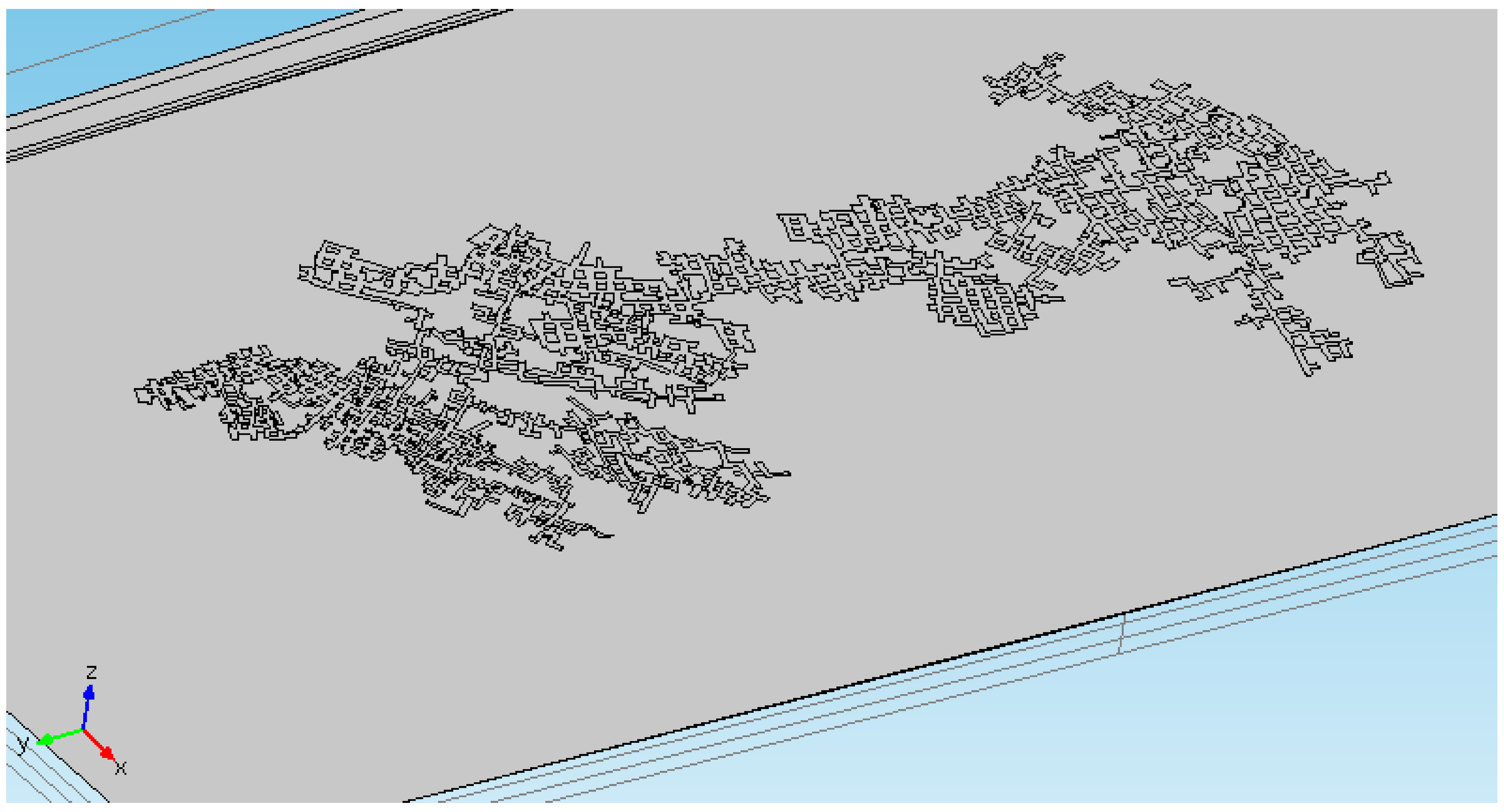

Figure 2. The 1110 x 580 x 31.5 m^3 3D geometry

Results: As you can see in figure 3, not all pillars have to endure the same level of stress (from 0.7 to 2.6 MPa). Also, the stresses are not homogeneously distributed inside the pillars. At the top edges the stresses are the highest, it is here where the first cracks usually appear.
The displacement in the pillars are generally consistent with the stress results (figure 4). But, the maximum displacement occurs in the roof direct above de mine galleries (figure 5).

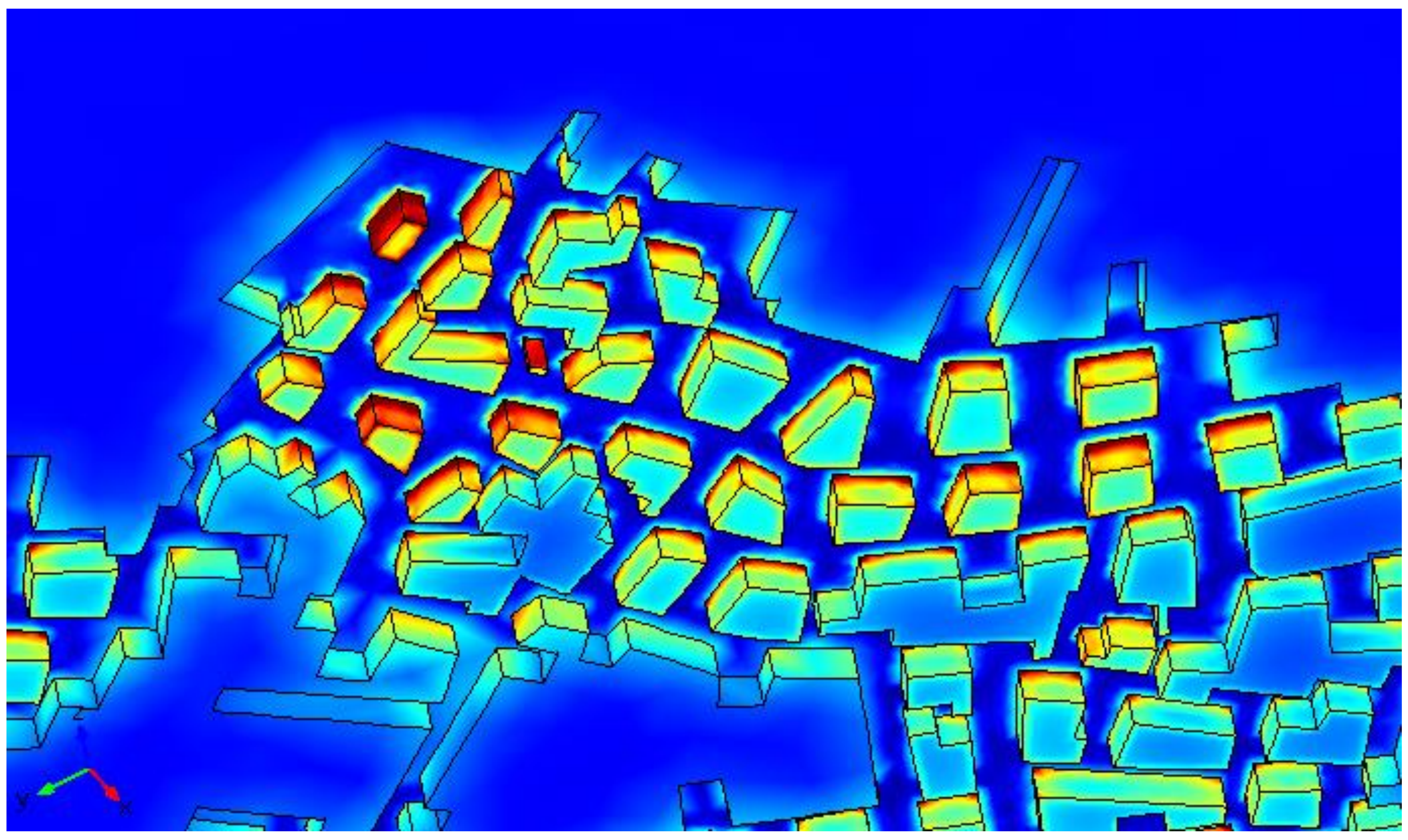

Figure 3. Stress distribution (3D bottom view)

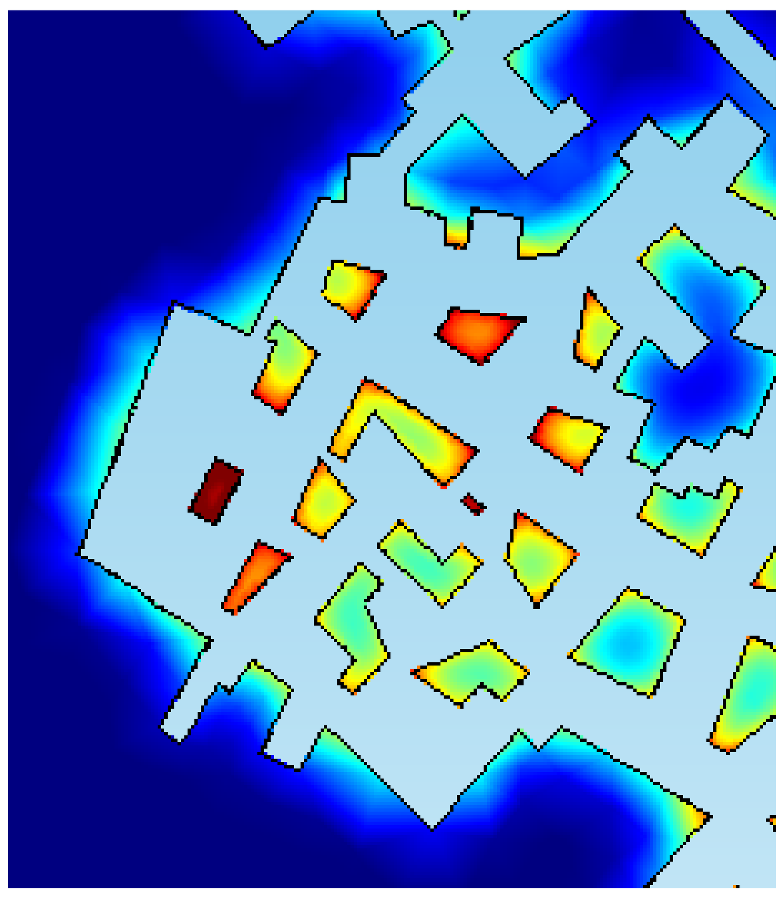

Figure 4. Vertical displacement (top view)

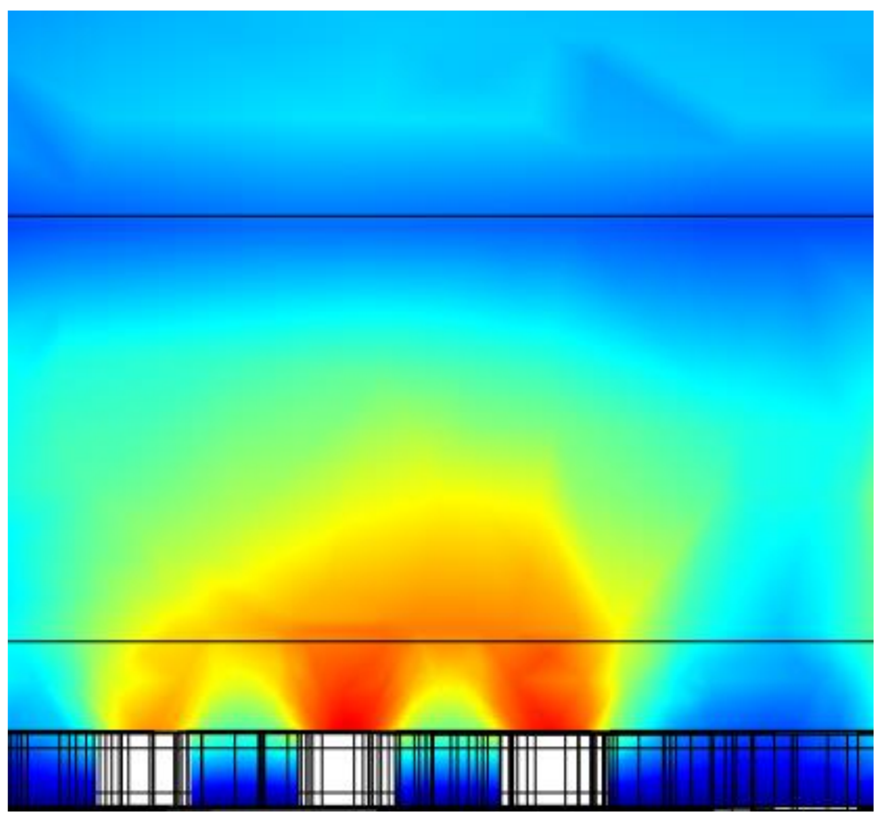

Figure 5. Vertical displacement (side view)

Conclusions: When the simulation results are compared with the real pillar damage they are clearly consistent, thus confirming that the simulation is a realistic representation of reality. In the near future this simulation will be further enhanced with a third study step which calculates the long-term plastic deformation called creep.