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Deterministic evaluation of collapse risk for a decomissioned flooded mine system: 3D numerical modelling of subsidence, roof collapse and impulse water flow.

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Aim of the study is the assessment of stability conditions for an abandoned gypsum mine (Bologna , Italy). Mining was carried out til the end of the 70s by the room and pillar method. During mining a karst cave was crossed karstic waters flowed into the mine. As a consequence, the lower level of the mining is completely flooded and portions of the mining levels show critical conditions and are structurally prone to instability.
Buildings and infrastructures are located above the first and second level and a large portion of the area below the mine area, and just above of the Savena river, is urbanised.
Gypsum geomechanical properties change over time; water, or even air humidity, dissolves or weaken gypsum pillars, leading progressively to collapse.
The mine is located in macro-crystalline gypsum beds belonging to the Messinian Gessoso Solfifera Formation. Selenitic gypsum beds are interlayered with by centimetre to meter thick shales layers.
In order to evaluate the risk related to the collapse of the flooded level (level 3) a deterministic approach based on 3D numerical analyses has been considered. The entire abandoned mine system up to the ground surface has been generated in 3D. The considered critical scenario implies the collapse of the pillars and roof of the flooded level 3.
In a first step, a sequential collapse starting from the most critical pillar has been simulated by means of a 3D Finite Element code. This allowed the definition of the subsidence basin at the ground surface and the interaction with the buildings in terms of ground displacements. 3D numerical analyses have been performed with an elasto-perfectly plastic constitutive model.
In a second step, the effect of a simultaneous collapse of the entire level 3 has been considered in order to evaluate the risk of a flooding due to the water outflow from the mine system. Using a 3D CFD (Continuum Fluid Dynamics) finite element code the collapse of the level 3 has been simulated and the volume of outflowing water has been quantified together with water velocity and pressure.
On the basis of the results the remediation measures have been defined and the risk evaluated with a deterministic approach.