DELIVERABLE D3.2.

INDIVIDUAL PARTNER REPORTS ON DEVELOPED NUMERICAL MODELS RELATING TO MINE WATER ISSUES – SUMMARY

Task 3.2: Modelling and simulation of impacts on surface stability

Task 3.2 focuses on modelling climatic impacts on the stability of mining structures and works, specifically following changes in precipitation brought about by climate change. It consists of two subtasks: Subtask 3.2.1 analyses the stability of surface mining features; Subtask 3.2.2 analyses the stability of surface features impacted by underground mine workings.

Sub-task 3.2.1.: Stability of surface mining features

Results of works within Sub-task 3.2.1 are presented in 4 separate reports.

CERTH investigated the effect of rain events in sinkholes' formation. This effect was initially evaluated and reported based on literature, outcomes derived from previous research, and experience. An overview was presented on the primary factors and mechanisms contributing to the occurrence of sinkholes within the mining context. Subsequently, numerical modelling and particularly the finite element method was employed to implement and analyse in various ways the effect of rainfall and groundwater changes on the stability of shallow coal mines. To that end, a well-documented case history from the literature was used and appropriately adapted to the planned investigated aspects. Moreover, CERTH systematically examined the slope stability of deep surface excavations under the effect of rainfall infiltration through an extensive numerical investigation. CERTH focused on lignite (brown coal) mining, where very deep excavations (up to 200m) on fine-grained soils are employed as typical examples. A general numerical framework was used to analyse the stability of the slopes under the effect of rainfall infiltration. This framework combined (a) the finite element method for computation of pore water pressures changes (mainly suctions' reduction) due to rainfall, (b) the limit equilibrium method for stability assessment in terms of the safety factor, and (c) the Monte Carlo simulation technique for reliability assessment of stability. Analyses were conducted considering the soil's friction angle and cohesion (i.e., the shear strength parameters) as random variables, so the geotechnical uncertainty was explicitly considered, and the probability of slope failure was computed. In addition, given the rainfall infiltration and the consideration of shear strength parameters as random variables, the relative contribution of six other critical parameters was investigated through parametric studies.

Furthermore, SUBTERRA developed a numerical model that studied the stability of a tailings dam under different climate scenarios. These scenarios focus on extreme events due to changes in precipitation. With the temporary groundwater level data obtained in the previous tasks by accessing different piezometers, a series of scenarios have been elaborated that are foreseeable in the southern area of the Iberian Peninsula. The scenarios simulated groundwater level rises and falls within the tailings dam area, trying to adjust to the climatic prognosis, according to the available groundwater level data as well as the analyses carried out in WP1 regarding climatic change analysis. The results of this model will serve as a basis for the risk analysis required in WP4. The elaboration of a functional base model will allow the identification of the most critical impacts in this type of structures, such as the geometry or the geomechanical properties of the materials used in the construction.

GIG and TWD worked on the implementation of slope reinforcement of mine waste dumps against the impact of extreme weather events (identified in WP1) near the Janina mining site in the area of Krakowska Street, Libiąż (PL). Due to extreme droughts and excessive rainfall, erosion and subsequent slope instability at the pilot site were already observed by TWD since 2016. The extreme rainfall in 2017 led to the slope collapsing and the need for reconstruction. Hence, this area became the pilot area of TEXMIN project. Numerical modelling was applied to propose the reinforcement of the slope at the Janina m mine waste dump. Based on the obtained data, several factors were considered to determine the possible significant influence of rainfall on slope stability. In the case of slope instability, reinforcement of the mining waste heap slope against the impact of extreme weather events at the Janina mine site was proposed, assigned and recalculated. The results of numerical modelling indicate a loss of slope stability under the influence of short-term high intensity rainfall. In such a case, the velocity value is higher than the permissible value, while the slope is considered stable in the case of the selected reinforcement, where the velocity value is high and permissible. Furthermore, in order to evaluate the effectiveness of the applied reinforcement, an accurate 3D model was built based on a scan of the slope made by the SUT. Further scanning results, which will be compared with the 3D numerical simulation, will quantify the results of the application of reinforcement. As a result of the work of WP3, it was possible to implement a pilot project (as part of WP4), which will be described in report D4.1.

Finally, VUHU investigated the conditions of the Most Basin using a geological model, focusing on the modelling of soil erosion losses due to precipitation and other parameters. VUHU has a working model of Most lake slopes and lots of data about large dumps and the Krušné hory Mts. Slopes based on RockWork15, a software with application in the petroleum, environmental, geotechnical, and mining industries. The erosion calculation is based on the Wischmeier-Smith universal equation methodology. The case study area of interest consists of two areas on the former Medard open-pit mine (Sokolov coal basin). Both areas are situated on the inner quarry hoist and were selected as risky, especially due to slope slopes. The soil erosion model is based on average annual precipitation, anti-erosion measures, and other parameters. Overall, precipitation has a significant impact on erosion. This application can be used for reclamation and revitalization purposes, which are most affected by the precipitation changes.

Sub-task 3.2.2.: Stability of surface features impacted by underground mine workings

Results of works within Sub-task 3.2.2 are presented in 2 separate reports.

SUBTERRA analysed the possible instabilities that can occur on a natural hillside located over an old underground mined area. A real scenario has been studied, located in the northwest of the Iberian Peninsula. For a correct symbiosis between the studied projections derived from climate change and the numerical stability model, a hydrogeological model has been developed to calculate the variations in the groundwater table according to different extreme precipitation scenarios. Different scenarios have been developed, incorporating realistic extreme increases and decreases in the groundwater level foreseeable in the region studied. The numerical model calculates the displacements in the hillside area influenced by the old underground galleries. The scenarios try to be as realistic as possible. However, an additional scenario with different geometrical conditions has been included to analyse the effects of changes in precipitation in other similar scenarios since variations in the geometry of the model or coal extraction method can represent a high variability in the numerical model results.

GIG, with the support of SRK, undertook numerical modelling for simulating the behaviour of rockmass and stability of shafts affected by increased water inflow by modelling current and future conditions. The work was done for six test sites (mine shafts) identified within Task 2.1 (Subtask 2.1.3). The local geological and technical conditions, including rocks lithology and strength parameters, shaft lining type, backfilling material, and shaft liquidation method, were represented in numerical models using FLAC 2D. The results of numerical calculations were presented in the form of displacement maps and displacement velocity vectors. In all cases, the maximum vertical displacements of the charging column did not exceed 50 cm, being considerably small (low) due to the depth of the shafts (hundreds of meters). The most significant horizontal displacements are found in shaft entrances with a value from 3 to 8 m. Under the influence of a large amount of water, the backfill material was washed away in the lower inlets. The results show that under the influence of a large amount of water, the backfill material will be instable in the lower inlets, but the behaviour of the entire column will be stable. In practice, when liquidating shafts, insulating-retaining or resistance-filtering dams in the inlets will be made of solid bentonites that block the movement of the filling material in the inlets. In addition, hydro-insulating layers will also be made in the backfill material column, which reduces the inflow of water into the shaft.