Open Pit Slope Stability Design Using Surpac & Slide: How SNC Lavalin Put Technology To Work For Them

Nadine Miller is a Geotechnical Engineer-in-Training with SNC-Lavalin Engineers in Toronto, an active practitioner who is savvy about using the latest software to her advantage in her geotechnical practice. “In the past, I felt frustrated by the amount of time it takes to set-up a model prior running the analysis. I’m always on the look out for ways to improve my analyses and cut my modelling time.” On a recent project, Nadine decided that the best tools were two different, but complimentary software packages, Surpac and Slide: “Using these programs, I was able to more efficiently model and analyse open pit stability.” Here Nadine describes her open pit project and explains how she was able to create a successful final stability model that has been accepted by international and third party reviewers.

“Our project area was a small-scale open pit mine located in Europe. The project was at the basic engineering stage and there were plans to eventually do conventional open pit mining of four pits for precious metals. We collected information for the project from the site’s original geological and geomechanical reports, from data gathered in similarly mined galleries and from our investigations of the current pit. We were able to confirm what the old reports suggested, that the pit area was well drained by existing underground mine workings: the four pits are connected at the principal mine level, with groundwater draining out of one adit that daylights in a neighbouring valley. There were three main rock types found at the location: dacite (ore bearing), vent breccia and black breccia.” SNC Lavalin’s team undertook both geological and geomechanical exploratory drilling: “In our geological program, we drilled several hundred exploratory holes to allow us to define reserves and orebodies in our mining model and less than 10 holes for our geomechanical program.” Data from these drilling programs was used to develop a mining model and to assess the stability of each pit using Surpac and Slide, respectively.
During the geomechanical program, a unique weathering pattern in the black and vent breccias and the discovery that breccia encased the dacite formation led Nadine’s team to determine that breccia lay under the dacite pit walls. They used this data to assess failure possibilities and decided that circular type failure dangers existed in the breccias, because of their similarity to soil. For the benches composed of dacite, localized failure wedge/planar failure was considered. "We undertook highwall modelling for the circular sliding surface using circular failure with the known mechanical properties of the rockmasses. The dacite, with its similarity to hard fractured rock, was analyzed using Hoek-Brown criterion. Because of its soil-like qualities, the breccias were modelled using Mohr-Coulomb. Next, we assessed ground water conditions at the pits to incorporate into the model. Using Slide’s groundwater modeling module, we were able to incorporate drainage conditions from the four open pits and the derived boundary condition based on seepage analysis preformed in an adjoining valley." It was assumed, based on the underground workings, in the groundwater model, that the periphery of the pit would be fully drained down to the principal mine level that connects all four pits: “The interior of the pit would be drained to the pit base through de-watering; boundary conditions were based upon watershed boundary conditions. After the groundwater model was run, the results established a future water table that was used for stability analysis.”

The initial evaluation of the open pit slope stability was based on simplified geological cross-sections from the geomechanical drilling program, simplified pit geometry and preliminary pit depths based on the feasibility study. One particular section, based on a single drillhole that intersected the overall slope of the feasibility pit shell, was entirely composed of black breccia. Once the maximum overall slope angle was assessed, the mine designers proceeded to develop their pit shells using Surpac: “During discussions with the designers, it became apparent that it was possible to select a cross-section of the natural ground surface and pit shell in Surpac and export it as file in DXF format. We could also export the geological data by including it in the cross-section. Using the two programs, we were able to evaluate a section based on a larger geological database, while still using our geomechanical parameters. This gave us the
flexibility to update our model to the most recent mine design and incorporate a larger database from which we could base our rock mass contacts, final pit shell geology and corresponding sub-surface geology with little to no additional time cost.” The team then re-analyzed the updated sections based on the complete Surpac model (Figure 1). Nadine adds that for the geomechanical parameters obtained during this program, factors of safety of the pit walls were computed using Bishop’s method. She says she expects that additional iterations will be required to verify the geological assumptions used in the pit slope stability analysis during the next stage of detailed design, the result of which could even further improve and optimize the overall pit slope configuration.

Figure 1 Slide Model Geometry Imported as SURPAC DXF File

After hearing about SNC Lavalin’s technology forward approach to their project, we were curious: why did they decide to use Slide in combination with Surpac? “The primary reason we chose Slide is that it allows users to import geometry from programs such as AutoCad and Microstation using a DFX format. The second reason is that the automatic mesh generation feature in Slide’s groundwater modeling module saves a lot of time. By combining two powerful engineering software packages, our modeling set-up time was reduced significantly and we produced internationally accepted results.”