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Interactive three-dimensional management of data from technological control of stacks and dams – case study

Gestion tridimensionnelle interactive des données du contrôle technologique des pieux et des barrages – étude de cas

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ABSTRACT: Innovations in geotechnics in the mining field have been constant, aiming to evolve construction techniques and the management of the generated information throughout the work. In order to provide a practical, fast and efficient methodology for data management of stacks and dams, it was developed the first interactive 3D model focused at the technological control of these structures. Geotechnical constructions are dynamic and complex, in addition, they are large constructions, new layers are compacted every day and several tests are carried out, which must be in accordance with the norms and technical specifications of the project. In this way, the importance of the possibility of critical analysis in real time is evident, making it able to avoid future problems. By integrating the project implemented with the Cesium geospatial model platform into the Geolabor, geotechnical data management system, a complete three-dimensional view is generated, which associates geometry with information. The 3D model is updated in real time, automatically and without the need for any programming or modeling skills from the user. The geometry of the as-built model is associated with the information that is registered in Geolabor throughout the construction, allowing the visualization in scales of colors of the evolution of the work, of the samples, tests and their respective geotechnical parameters and the compliance with the project technical specifications. This article presents a case study carried out in a waste and tailings stacks of the mining company Samarco, presenting the practical advantages of using the 3D model integrated to Geolabor.

RÉSUMÉ: Les innovations géotechniques dans le domaine minier sont des techniques de construction et une gestion des informations générées sur site constantes et en évolution. Dans le but de fournir une méthodologie pratique et efficace pour la gestion des données des pieux et des barrages, le premier modèle 3D interactif axé sur le contrôle technologique de ces structures a été développé. Les constructions géotechniques sont dynamiques et complexes, en plus d'être des constructions à grande échelle et chaque jour de nouvelles couches sont compactées et divers tests sont effectués, qui doivent répondre aux normes et spécifications techniques du projet. De cette manière, l'importance de la possibilité d'une analyse critique en temps réel devient évidente, contribuant ainsi à éviter de futurs problèmes. En intégrant le projet mis en œuvre avec la plateforme de modèles géospatiaux Césio dans le système de gestion des données géotechniques Geolabor, une vue tridimensionnelle complète est générée, combinant la géométrie et l'information. Le modèle 3D est mis à jour en temps réel, automatiquement et sans aucune connaissance en programmation ou modélisation de la part de l'utilisateur. La géométrie du modèle as-built est associée aux informations enregistrées dans Geolabor tout au long de la construction, permettant la visualisation en échelles de couleurs de l'évolution de la structure, des échantillons, des tests et des paramètres géotechniques respectifs et du respect des spécifications techniques du projet. Cet article présente une étude de cas réalisée sur une décharge et une halde à déchets Samarco, présentant les avantages pratiques de l'utilisation du modèle 3D intégré à Geolabor.

Keywords: Three-dimensional model; data management; stacks and dams; mining geotechnics; technological control.

1 INTRODUCTION

Despite essential for the safety, geotechnics did not always follow clear regulations regarding the practice of its exercise (Araújo, E. R., 2016). Over the past few years, the search for innovation in the mining geotechnical field has been growing, seeking to develop new methodologies, norms and good practices that help prevent possible new disasters involving stacks and dams around the world. With technological progress, this process of evolution becomes constant, in order to guarantee the safety and compliance of the constructions.

In this scenario, the importance of carrying out careful technological control and the use of a

centralized and structured data management system has been gaining prominence in the geotechnics practice (de Lacerda, B. M., 2023). Technological control is the process that ensures that technical design specifications are met throughout construction. In order to optimize this process and assist in critical decision-making, the first interactive three-dimensional model aimed at managing geotechnical data for the technological control of stacks and dams was implemented by de Lacerda, B. M. (2022).

The 3D model was implemented using the Cesium platform, a complete tool for developing spatial models of different types. Using Cesium JS, all internal programming of the model was performed, automating the entire creation of the geometry of the geotechnical structure, based solely on the data collected during technological control. Without the need for user knowledge in modeling or programming, this model is an innovation for the geotechnical area.

The main objective of this article is to present the integration of the 3D model developed into a geotechnical data management system, Geolabor, enabling automatic and real-time updating of geometry and associated information, in accordance with the construction of the structure. Geolabor operates in all engineering processes, from planning, execution, and conducting analyses to issuing reports. Geolabor is a software in constant development, which seeks evolution and innovation daily, pioneering the practice of different methodologies that increase the safety of geotechnical constructions, guaranteeing the quality of the works.

After integrating the 3D model into the Geolabor system, both the geometry and the information associated with the structure are now updated in real time, according to the natural use of Geolabor in the technological control. To make use of the 3D model, nothing different from the routine of technological control needs to be done, as the system utilizes the information registered in the data management system to create and update the geometry and information contained in the 3D model. The 3D as-built model allows a practical visualization of the progress of the work, facilitating the control of geometry, samples, compliance with the technical design specification criteria and geotechnical parameters obtained in tests carried out throughout construction.

2 CASE STUDY

In order to put into practice the three-dimensional data management model integrated in Geolabor, a case study was developed with the mining company Samarco. The 3D model was implemented at PDER Alegria Sul (Tailings Storage Facility – TSF Alegria Sul), located at Mine Alegria Sul of Samarco (Mariana, MG/Brazil); a shared disposal stack of waste rock and filtered tailings, where the layers of landfill are built following thickness and compaction controls (Simplelab, T., 2022). The main objectives of this study are to highlight the practical importance of using the 3D model developed in the day-to-day life of a geotechnical construction, using real data.

The Samarco team uses Geolabor to manage technological control at PDER Alegria Sul and used Geolabor's 3D module for a month to carry out analyzes of this case study. Figure 1 presents the three-dimensional visualization of the stack under study.

Figure 1. PDER Sul Three-dimensional as built model.

It is possible to observe in Figure 1 that the model developed has no restrictions on the geometry of the structure, following the normally irregular shapes of tailing stacks. The model is built based on a methodology that takes into account the information that is collected throughout construction, as layers thickness and topographic data. The input of the coordinates (E, N, and Z) of the polygonal of the layers can be done manually or from a .csv file, with no need for any drone flights or point cloud file.

To create the initial model of a project that was already in progress before the start of implementation of the 3D module, only information relating to the last two compacted layers is required. The coordinates of the subsequent layers are inferred by the system, building the complete model with all layers registered in the Geolabor. Throughout the construction, it is not mandatory to register the coordinates of all built layers, as these are inferred by the system and automatically created in the 3D model. However, the more layers have their coordinates registered; the closer to reality the visualization will be, although the inference of coordinates does not affect the use, efficiency and interactivity of the 3D model for technological control.

All geometry is associated with information, constituting a complete model for managing the

geotechnical data of stacks and dams. Being completely interactive, when clicking on a certain layer, its respective information is displayed, such as elevation, start and end dates, status, volume, and acceptance criteria, as shown in Figure 2 below.

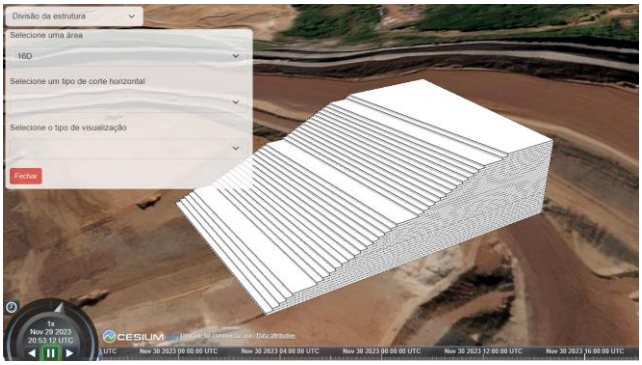
Figure 2. Visualization of information registered in Geolabor for a specific layer, when selected in the 3D model.

In addition to visualize the layers and their information, it is also possible to view all the samples collected throughout the construction and registered in Geolabor, as shown in Figure 3. Without losing interactivity in any of its features, when clicking on a specific sample, they information relating to the selected sample are displayed, also including the tests that were carried out on this sample and the geotechnical parameters obtained in each test.

Figure 3. Representation in the 3D model of samples registered in Geolabor for the PDER Alegria Sul stack.

From Figure 3, it is possible to observe, in a practical and immediate way, that there is at least one sample with its coordinates registered with some error, since there is a point outside the space of the structure. This type of verification is one of the direct advantages of using the 3D module, where it becomes possible to guarantee the conformity of construction records, with complete management of construction technological control data.

Geolabor allows areas and subareas to be specified in the system, so that technological control can be carried out in a personalized way for each project, as makes the most sense for the user. In the 3D model, it is possible to view and filter each of these areas or make horizontal cuts in the structure, by elevation or by layer, enabling a careful view of the division of the structure and the construction progress, as shown in Figure 4 below.

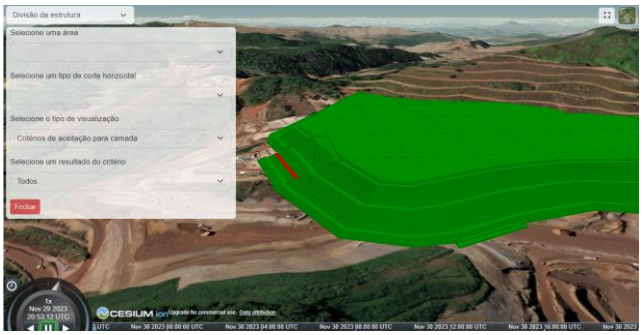


(a)

(b)

Figure 4. (a) Representation of a specific subdivision of the stack; (b) Horizontal cut to visualize a specific layer or elevation.

Once the technical project specifications are registered in the system, upon completing a test, it is calculated whether the geotechnical parameters obtained are within the previously specified limits, and the acceptance of the project criteria is presented in Geolabor. It is then possible to visualize these results in color scales on the 3D model, and filter the areas and layers according to what is registered, as shown in Figure 5.



(a)

(b)

Figure 5. (a) Color scale visualization of compliance with technical specifications; (b) Filtering to visualize layers that did not meet the requirements of the registered technical specifications.

With the 3D model use, it was possible for the Samarco team to verify that there were typing errors in the registration of some layers. As can be seen in Figure 4, the layers in red would have the status of "did not comply", as they did not comply with the acceptance criteria, however, carrying out a critical analysis, registration errors were found. It was also possible, just by using the model, to verify that there were obsolete or duplicate criteria registered in the system. Previously, all this information was compiled in Excel spreadsheets, which are no longer necessary on a day-to-day basis with the full use of Geolabor and its features.

3 CONCLUSIONS

The case study carried out allowed to verify the practical usefulness of the 3D model integrated into Geolabor, presenting satisfactory results. The Samarco team was satisfied with the use of the functionality, and excited for future implementations, which are already in the development phase.

In the next work, the Heatmap will be implemented, allowing the visualization of the results of the geotechnical parameters obtained in the tests carried out, in a color scale and in the form of a three-dimensional graph. The functionalities to be developed later will be defined according to the practical needs of geotechnics, always seeking innovation, practicality and quality in the process of technological control of stacks and dams.

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