Proceedings of the XVIII ECSMGE 2024
GEOTECHNICAL ENGINEERING CHALLENGES
TO MEET CURRENT AND EMERGING NEEDS OF SOCIETY

ISBN 978-1-032-54816-6
DOI 10.1201/9781003431749-267

ECSMGE 24
XVIII EUROPEAN CONFERENCE ON SOIL MECHANICS AND GEOTECHNICAL ENGINEERING

Insights from the implementation of levelAMS, a geotechnical asset management software, on Brisa's network

Aperçu de la mise en œuvre de levelAMS, un logiciel de gestion des actifs géotechniques, sur le réseau de Brisa

J. Barros*, M. Pinheiro
Level company, Braga, Portugal

M. Cruz, I. Gonzalez
Brisa, SA, Lisboa, Portugal

T. Miranda
University of Minho, Guimarães, Portugal

**julianabarros@level-gam.com*

ABSTRACT: LevelAMS is a cutting-edge asset management software designed for extensive geotechnical assets networks. This cloud-based platform integrates a comprehensive suite of services and features aimed at optimizing daily operations and resources for concessionaires. Its primary objectives include enhancing safety measures and minimizing geotechnical hazard risks. In addition to maintaining an inventory of assets, LevelAMS offers a user-friendly experience by enabling visual inspections, work scheduling, and comprehensive data storage for registered occurrences and accidents. The platform goes beyond basic functionalities by providing users with access to risk maps and a condition index.This study provides initial insights into the utilization of LevelAMS within the Brisa geotechnical network, encompassing 11,837 slopes (embankments and cuts) and 570 retaining walls of diverse types. The vast and heterogeneous nature of this network, spanning over 1,100 km, underscores the imperative for advanced asset management software and risk mitigation tools. Noteworthy advantages of LevelAMS include the ability to categorize asset conditions, identify urgent intervention needs, and closely monitor assets on a daily basis.

RÉSUMÉ: LevelAMS est un logiciel de gestion d'actifs de pointe conçu pour les vastes réseaux d'actifs géotechniques. Cette plateforme basée sur le cloud intègre une suite complète de services et de fonctionnalités visant à optimiser les opérations quotidiennes et les ressources des concessionnaires. Ses principaux objectifs consistent à améliorer les mesures de sécurité et à minimiser les risques géotechniques. En plus de maintenir un inventaire des actifs, LevelAMS offre une expérience conviviale en permettant des inspections visuelles, la planification des travaux et le stockage complet des données pour les occurrences et les accidents enregistrés. La plateforme va au-delà des fonctionnalités de base en offrant aux utilisateurs l'accès à des cartes de risques et à un indice de condition. Cette étude fournit des premières impressions sur l'utilisation de LevelAMS au sein du réseau géotechnique de Brisa, comprenant 11 837 pentes (remblais et coupes) et 570 murs de soutènement de différents types. La nature vaste et hétérogène de ce réseau, s'étendant sur plus de 1 100 km, souligne l'impératif d'un logiciel de gestion d'actifs avancé et d'outils de mitigation des risques. Les avantages notables de LevelAMS comprennent la possibilité de catégoriser les conditions des actifs, d'identifier les besoins d'interventions urgentes et de surveiller de près les actifs au quotidien.

Keywords: Geotechnical asset management; risk mitigation tools; asset's condition; Brisa's network.

1 INTRODUCTION

LevelAMS is a sophisticated geotechnical asset management software designed for daily use, providing decision-makers with optimized tools to effectively manage their assets. The management of linear assets, which often constitutes a substantial number, requires a standardized and streamlined process to mitigate geotechnical accidents resulting from asset degradation. In response to this need, levelAMS offers a comprehensive and integrated solution for the monitoring and management of such assets.

This work aims to provide a detailed overview of the asset management software, outlining its features, advantages, and its practical application within a real motorway network.

Brisa, a private motorway concession company based in Portugal, boasts an extensive network of over

1100 km of motorways. Despite the meticulous management of various assets, geotechnical assets are frequently lacking a fully assessed management process. Recognizing this gap, there is an imperative to digitize and integrate the management of these assets for enhanced efficiency and comprehensive oversight.

2 BRISA'S NETWORK

Brisa's Motorway Concession (BCR) is a private Portuguese company within the Brisa Group, tasked with overseeing the management of an extensive motorway network spanning over 1100 km. The network comprises 12 highways that traverse from the north to the south of Portugal, encompassing critical road axes in major cities such as Lisbon and Porto (Figure 1).

Within the scope of Brisa's geotechnical assets, there exists a total of 12,406 assets, categorized into slopes and retaining walls with 11,836 and 570 assets, respectively. Approximately 60% of the slopes consist of cuts, while the remaining 40% are embankments, varying in length from 6 m to 2200 m and reaching a maximum height of 50 m. Notably, around 10% of the slopes are protected with shotcrete.

In terms of retaining walls, they exhibit diverse characteristics, with a maximum length of 1400 m and a height of 24 m. The various types of retaining walls include gabion, cantilever, gravity walls, and a few reinforced soil or concrete walls, with or without anchors.

The lithology of the network is notably heterogeneous. In the northern region, slopes are predominantly composed of granite and schist, while the central region features mainly sandstones and limestones. In the southern region, the prevalent geological composition consists mostly of sands and limestones.

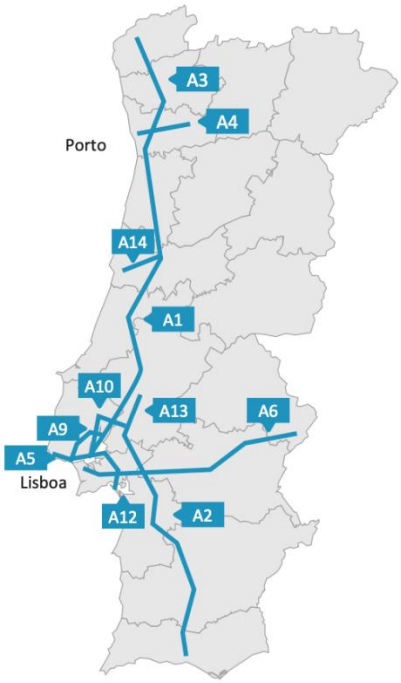

Figure 1. Brisa's motorway network.

3 GEOTECHNICAL ASSET MANAGEMENT

3.1 LevelAMS description

LevelAMS is a comprehensive software solution designed for the management and risk assessment of geotechnical assets, specifically focusing on retaining walls and slopes. This innovative solution encompasses a range of features, including a database with an inventory of geotechnical assets, mobile platforms for on-site inspections and incident recording, interactive risk maps utilizing a 5-level scale, and a customizable dashboard presenting network analytics for retaining walls and slopes.

This geotechnical asset management software effectively addresses the primary requirements of asset management, including inventory management, risk assessment, documentation of visual inspections, recording of occurrences, and the planning of conservation and maintenance efforts. The efficiency of this management is facilitated through a georeferenced database that houses both inventory information and data collected during visual inspections and incident recording. The standardization and centralization of these processes contribute to enhanced asset management effectiveness and improved cost control.

LevelAMS employs a qualitative and quantitative classification system for assets, utilizing a condition index developed as part of an academic research project (Pinheiro et al., 2015). This condition index,

informed by various factors directly and indirectly linked to asset stability and condition, enables the establishment of risk levels and identifies geotechnical assets requiring closer monitoring or conservation actions. The outcome is a more streamlined and economically efficient management approach for geotechnical assets.

It is worth noting that the system and its associated processes are flexible and can be tailored to the specific needs and realities of road management companies, accommodating diverse characteristics and complexities within their road networks.

3.2 LevelAMS main features

In addition to the previously highlighted features, the key functionalities of levelAMS are summarized in Table 1. These core functionalities comprehend a customizable dashboard, an extensive assets database, a module for warnings and inspections lists, risk maps with filter options based on risk levels, and a financial analysis module. The financial analysis module serves to compare the annual budget with the actual execution, providing valuable insights into budgetary performance. This comprehensive set of features ensures that levelAMS offers a versatile and robust solution for the efficient management and assessment of geotechnical assets.

Table 1. levelAMS main features description.

	Modulus	General Description
1	Dashboard	Analytical representation of the most relevant data of the assets network: number of assets by condition index, number and type of inspections, work and incidents carried out or registered, and the severest inspections results
2	Assets	Georeferenced inventory database, which contains all the information for each of the geotechnical assets (retaining walls and slopes)
3	Warnings	Alert system for all assets network that is triggered whenever: an incident is registered; a given instrument registers a value higher than the predefined threshold; and the condition index exceeds a predefined value
4	Risk maps	Depending on the condition index, assets are classified according to their level of risk on a qualitative scale (very low; low; moderate; high; very high) and quantitative ranging from 1 to 5. Risk maps are georeferenced using a colour scale to identify the associated asset risk
5	Continuous Monitoring	Optional functionality. Allows you to visualize through a map the assets that include continuous monitoring
6	Financial analysis	It allows an annual economic control of the network of assets, through the direct comparison of the budget value versus the real cost per road and concession for the different actions available
7	Reporting	Contains all the reports that summarizes all data and changes made about the asset or the assets network during a period of time to be selected
8	Inspections	Stores and show all inspections forms and details performed on the network

3.3 Asset condition index (CI)

The qualitative and quantitative classification of assets through a condition index was developed by Pinheiro et al. (2015) as part of a comprehensive scientific investigation conducted over several years in collaboration with the University of Minho. This condition index serves as a fundamental tool for characterizing and diagnosing the condition of retaining walls and slopes within the asset network.

During the operational phase, the utilization of this condition index proves invaluable in providing insights into the overall health of the assets network. The Condition Index (CI) allows users to classify slopes on a scale ranging from 1 to 5, where 1 indicates very good condition and 5 reflects a very poor condition. The index is based on various factors and parameters directly or indirectly linked to the stability of retaining walls and slopes. Each group of parameters is assigned different weights based on its relevance to slope and wall stability.

Importantly, these weights are adaptable to the specific characteristics and geographical nuances of road networks managed by concessionaires. Users have the flexibility to adjust the weights assigned to each factor and the parameters of the CI for each type of asset. Such customization enables a tailored approach, allowing for the incorporation of diverse network characteristics. Any adjustments made by the user will subsequently impact the calculation of the CI. For a detailed understanding of the CI calculation methodology, please refer to the publication by Pinheiro et al. (2015).

3.4 Risk Map

Based on the outcomes of the condition index, assets undergo classification according to their risk level on both a qualitative (very low, low, moderate, high, very high) and a quantitative scale ranging from 1 to 5. This dual-scale approach enables the identification of assets at the highest risk, pinpointing those requiring urgent interventions and specifying the type of necessary action.

Moreover, it facilitates the examination of the proposed monitoring plan, as outlined in Table 2, to be

implemented strategically in response to the assessed risk levels.

Table 2. Recommendation and indications to be adopted according to the risk level of the geotechnical asset.

Risk Levels	Inspections	Recommended actions	Temporal Space
Low	Routine inspections up to every 2 years Principal Inspections up to every 8 years	Only needs preventive or current maintenance actions	No relevant actions except for current maintenance
Moderate	Routine inspections up to every 2 years Principal Inspections up to every 4 years	Requires current maintenance actions and, possibly, conservation actions with the need for a design project	Medium Term Intervention
High	Routine inspections up to every 1 year Principal Inspections up to every 2 years	Dedicates a need for rehabilitation or replacement actions. However, complementary diagnostic actions (e.g., monitoring) may be necessary to mitigate associated risks	Short to Medium Term Intervention
Very high	Principal Inspections up to every 1 year	Requires immediate implementation of additional monitoring/diagnostic measures and conditioning for continued use	Short Term Intervention Immediate Mitigating Measures and Conditioning to Circulation

3.5 Degradation models

Utilizing the evolution of the Condition Index (CI) over time enables the visualization of the degradation curve for each asset, as can be seen in the example shown in Figure 2-a)). With real-time updates for every new entry in the software, users can observe the dynamic changes in the CI, providing insights into the asset's condition evolution.

Given that the CI is categorized into groups, users gain the ability to analyze the performance of each group and its contribution to the overall condition of the asset. This categorization facilitates a detailed examination of which specific aspects may be underperforming, offering valuable information to guide interventions and improve the overall CI of the asset. In the example shown in Figure 2-b), environmental conditions, visual inspections results and geological characteristics are the ones contributing to a poorer CI.

In essence, this feature empowers users with actionable insights, guiding them on where interventions are most needed to enhance the condition of the asset.

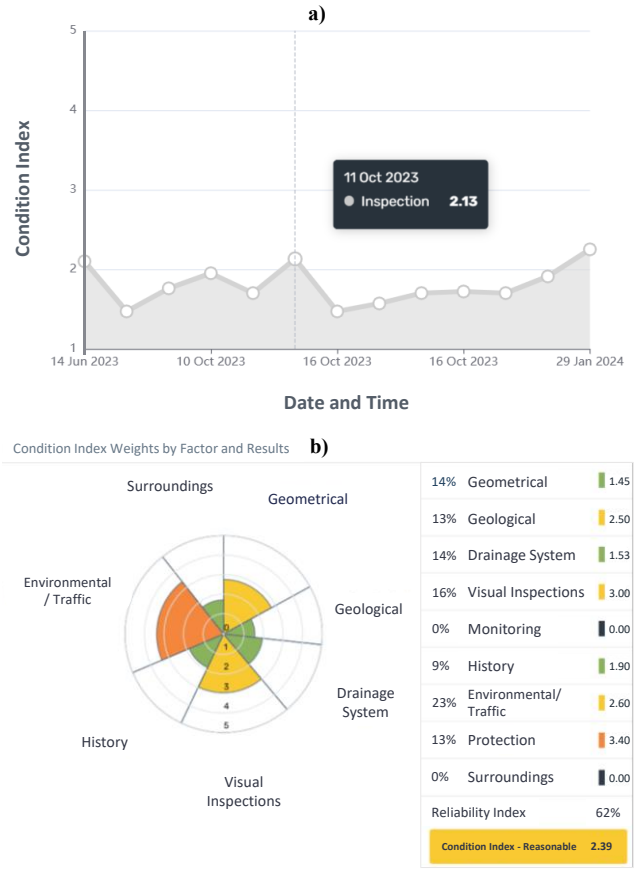

Figure 2. Degradation model graphic (a)) and details of group classification (b)).

4 RESULTS

The entire network of geotechnical assets has been successfully integrated into levelAMS, resulting in the classification of their condition into two classes: reasonable (8,396) and good (4,010), as illustrated in Figure 3. Despite the software 5 classes classification, most of the uploaded information are geometrical and traffic related. Moreover, environmental information remains the same for each asset. Therefore, the 5 classes are not fully represented by this initial set of assets. Regarding the parameters group that presents a relevant weight for the CI, namely geological and visual inspections there are no information uploaded. Although, it is important to mention that as more visual inspection are done, incidents and monitoring are registered, the assets group should obtain a more unfavourable class, mainly 4 or even 5.

The liability index, based on the amount of field information available, ranges from 48% to 66%. Notably, the reliability of the Condition Index (CI) increases with more comprehensive information.

Consequently, certain factors such as details about the surroundings, structural specifics, or geological data remain empty due to insufficient information. It is important to highlight that due to the lack of information, the amount of data imported for each asset is almost the same, therefore, the liability index remain quite stable. As more actions are done on levelAMS, meaning works or inspections added, this index should present a higher variation. According to maintenance actions, levelAMS provides a summary of the visual inspection helping decision makers to correct any pathologies observed. Since CI evaluates several parameters additional to visual inspections, the classes variation is reduced and controlled.

Following the initial campaign of inspections, some of the assets introduced in levelAMS have undergone assessment and monitoring. Critical assets that are instrumented can benefit from continuous monitoring using levelAMS, as depicted in Figure 4. Using the icon and colour scale it is possible to quickly identify the status of the monitoring system and understand if an alert or alarm threshold is reached (yellow and red, respectively). The software provides users with a user-friendly interface, offering real-time status updates of the assets and serving as a graphical display for the installed sensors. Additionally, warnings can be triggered and displayed if an asset surpasses a specified CI threshold.

Figure 3. 5-classes distribution of Brisa's network of geotechnical assets.

Figure 4. Critical asset network of sensors using icons (TM-tiltmeters, I-Inclinometers, P-Piezometers, O-Other) and colours (Green-sensors are OK, Red-alarm threshold and Gray-no connection).

5 CONCLUSIONS

This study provides initial insights into the newly developed geotechnical asset management software, levelAMS, implemented within Brisa's network. In addition to facilitating inventory management, the software enables the classification of assets based on their condition, utilizing the Condition Index developed by Pinheiro et al. (2015).

Centralizing all asset information within a single platform and enabling seamless processes for inspections, work registrations, and incident recording stand out as primary advantages of the software. To further comprehend the full spectrum of benefits, additional inspection campaigns are warranted. The platform's potential for risk assessment emerges as a significant advantage, particularly for the management of extensive asset networks.

This comprehensive mapping capability holds the promise of fostering a more strategic approach to short and long-term intervention planning. It also offers the ability to analyse the individual or macro-level condition evolution of slopes, thereby contributing to more informed and rational decision-making processes in geotechnical asset management.

ACKNOWLEDGEMENTS

The authors thank the Brisa Concessão Rodoviária for the provided information. The levelAMS results used on this work were obtained from levelAMS software, a cloud-based platform from level company.

REFERENCES

Level (2021). Level AMS- Asset Management Software v1 [cloud-based platform].

Pinheiro et al. (2015). A new empirical system for rock slope stability analysis in exploitation stage. International Journal of Rock Mechanics & Mining Sciences 76 (2015) 182–191. http://dx.doi.org/10.1016/j.ijrmms.2015.03.015.