



EXPLORING THE IMPACT OF LEVELAMS: GEOTECHNICAL ASSET MANAGEMENT SOFTWARE WITHIN BRISA'S INFRASTRUCTURE

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Abstract

This paper focuses on the introduction of levelAMS geotechnical asset management software. levelAMS is meticulously designed for daily use, empowering decision-makers with optimized tools to oversee linear assets efficiently. This work emphasizes the necessity for a standardized and digitized approach to manage geotechnical assets within extensive motorway networks, citing the case of Brisa's Motorway Concession in Portugal. It provides a detailed overview of the diverse characteristics of geotechnical assets, such as slopes and retaining walls, and underscores the software's features, advantages, and practical application. Notable features include the software's flexibility, dual approach to asset classification, and key functionalities like the Slope Quality Index (SQI), risk maps, and degradation models. The abstract concludes by highlighting the application of levelAMS within Brisa's network, showcasing its role in enhancing overall asset management efficiency.

Keywords: asset management, geotechnic, risk assessment

1 Introduction

levelAMS stands as a sophisticated geotechnical asset management software meticulously crafted for daily use. It equips decision-makers with optimized tools to efficiently oversee their assets. Managing linear assets, often comprising a significant number, necessitates a standardized and streamlined process to avert geotechnical incidents resulting from asset degradation. In response to this imperative, levelAMS presents a comprehensive and integrated solution tailored for the monitoring and management of such assets.

This undertaking aims to furnish a detailed overview of the asset management software, delineating its features, advantages, and practical application within an actual motorway network. Brisa, a private motorway concession company headquartered in Portugal, boasts an expansive network spanning over 1100 km of motorways. Despite the meticulous management of various assets, geotechnical assets frequently lack a fully assessed management process. Recognizing this void, there is an urgent need to digitize and integrate the management of these assets to enhance efficiency and provide comprehensive oversight.

2 Brisa's motorway concession (BCR): Overview of geotechnical assets

Brisa's Motorway Concession (BCR) operates as a private Portuguese company under the Brisa Group, entrusted with the management of an extensive motorway network spanning over 1100 km. This network encompasses 12 highways that traverse from the northern to the southern regions of Portugal, including critical road axes in major cities such as Lisbon and Porto (refer to Figure 1).

Within the realm of Brisa's geotechnical assets, a total of 12,406 assets are identified, categorized into slopes and retaining walls, comprising 11,836 and 570 assets, respectively. Approximately 60% of the slopes are 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 fortified with shotcrete.

Regarding retaining walls, they showcase 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 exhibits notable heterogeneity. In the northern region, slopes predominantly consist 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. Note that, these network does not take into account tunnels, since those are considered special and are analyses separately.



Figure 1 Brisa's motorway network.

3 Advanced geotechnical asset management

3.1 levelAMS

levelAMS [1] stands as a comprehensive software solution meticulously designed for the management and risk assessment of geotechnical assets, with a specific focus on retaining walls and slopes. This innovative platform integrates a suite of features, including an expansive database housing an inventory of geotechnical assets, mobile platforms facilitating on-site inspections and incident recording, interactive risk maps utilizing a 5-level scale, and a customizable dashboard providing network analytics for retaining walls and slopes. This geotechnical asset management software adeptly addresses the fundamental requirements of asset management, encompassing inventory management, risk assessment, documentation of visual inspections, recording of occurrences, and the planning of conservation and maintenance efforts.

The system's efficiency is propelled by a georeferenced database housing both inventory information and data collected during visual inspections and incident recording. The standardization and centralization of these processes significantly contribute to enhanced asset management effectiveness and improved cost control.

levelAMS adopts a dual approach to asset classification, utilizing both qualitative and quantitative methods. A condition index, developed as part of an academic research project [2] serves as the cornerstone of this classification system. Informed by various factors directly and indirectly linked to asset stability and condition, the condition index facilitates the establishment of risk levels and identifies geotechnical assets necessitating closer monitoring or conservation actions. The result is a more streamlined and economically efficient management approach for geotechnical assets.

It's noteworthy that the system and its associated processes are inherently flexible, allowing tailoring to the specific needs and realities of road management companies. This adaptability accommodates diverse characteristics and complexities within their road networks, ensuring a bespoke and effective solution for each unique context.

3.2 levelAMS key features

In conjunction with the features highlighted earlier, the pivotal functionalities of levelAMS are succinctly encapsulated in Table 1. These core functionalities encompass a customizable dashboard, an expansive assets database, a module dedicated to warnings and inspections lists, risk maps equipped with filter options contingent upon risk levels, and a financial analysis module. The financial analysis module plays a crucial role in comparing the annual budget against the actual execution, offering valuable insights into budgetary performance. This comprehensive array of features underscores levelAMS as a versatile and robust solution, ensuring the adept management and assessment of geotechnical assets with efficiency and precision.

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 SQI (slope quality index)

The qualitative and quantitative classification of assets through a condition index was meticulously developed by [2] as part of an extensive scientific investigation conducted over several years in collaboration with the University of Minho. This condition index stands as a fundamental tool for characterizing and diagnosing the condition of retaining walls and slopes within the asset network.

Throughout the operational phase, the application of this condition index proves to be invaluable, providing profound insights into the overall health of the asset network. The Slope Quality Index (SQI) empowers users to classify slopes on a scale ranging from 1 to 5, where 1 indicates excellent condition and 5 signifies very poor condition. The index is grounded in various factors and parameters directly or indirectly linked to the stability of retaining walls and slopes, with each group of parameters assigned differing weights based on their relevance to slope and wall stability.

Crucially, these weights are adaptable to the specific characteristics and geographical nuances of road networks managed by concessionaires. Users have the flexibility to fine-tune the weights assigned to each factor and the parameters of the SQI for each type of asset. Such customization facilitates a tailored approach, accommodating diverse network characteristics. Any modifications made by the user will consequently influence the calculation of the SQI. For an in-depth understanding of the SQI calculation methodology, please refer to the publication by [2].

3.4 Risk maps

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.

Moreover, the following risk matrix can be applied in order to define the mentioned classes. The criticality index takes into account the traffic usage of the road, their proximity to housing and services and the assets CAPEX.

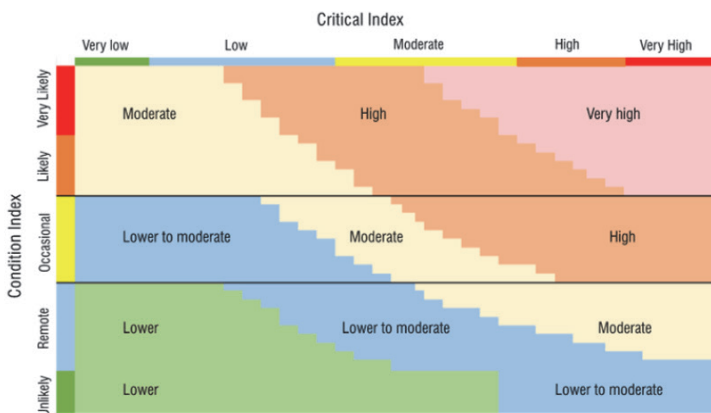


Figure 2 Risk matrix example

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

Tracking the evolution of the Condition Index (CI) over time allows for the visualization of the degradation curve for each asset. Real-time updates with every new entry in the software empower users to dynamically observe changes in the CI, providing crucial insights into the asset's condition evolution.

To further enhance the analytical capabilities, levelAMS incorporates Artificial Neural Networks (ANN) to withdraw degradation models. This advanced approach leverages machine learning to discern intricate patterns within the CI data, enabling the system to predict and model the degradation trajectory of geotechnical assets.

Given the categorization of the CI into groups, users acquire the capability to analyze the performance of each group and its contribution to the overall condition of the asset. This categorization facilitates a meticulous examination, pinpointing specific aspects that may be underperforming and thereby offering valuable information to guide interventions and improve the overall CI of the asset.

In essence, this feature, augmented by ANN, empowers users with actionable insights, directing them to the areas where interventions are most needed to enhance the condition of the asset.

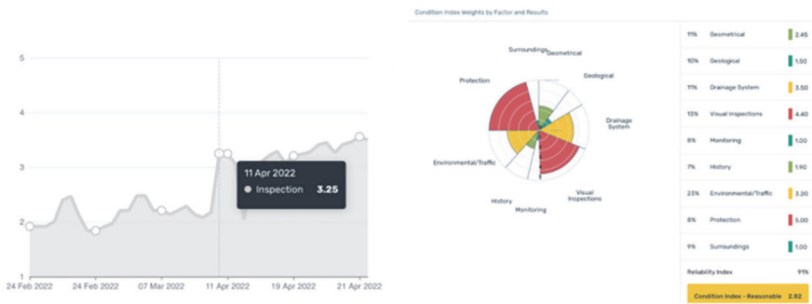


Figure 3 Degradation model graphic and details of group classification

4 The application of levelAMS

The entire network of geotechnical assets has been seamlessly integrated into levelAMS, resulting in the classification of their condition into two distinct classes: reasonable (8,396) and good (4,010). Although after a first campaign of inspection the assets condition indicators had change for reasonable (8,306) and good (4,090). of as illustrated in Figure 3. The liability index, based on the amount of field information available, ranges from 48% to 66%. It is noteworthy that the reliability of the Slope Quality Index (SQI) increases with more comprehensive information. Consequently, certain factors, such as details about the surroundings, structural specifics, or geological data, may remain unpopulated due to insufficient information.

Following the initial campaign of inspections, some of the assets introduced in levelAMS have undergone thorough assessment and continuous monitoring. Critical assets that are instrumented can now benefit from ongoing monitoring through levelAMS, as depicted in Figure 4. The software provides users with an intuitive interface, delivering real-time status updates of the assets and serving as a graphical display for the installed sensors. Furthermore, the system enables the triggering and display of warnings if an asset surpasses a specified SQI threshold, ensuring timely and informed decision-making.

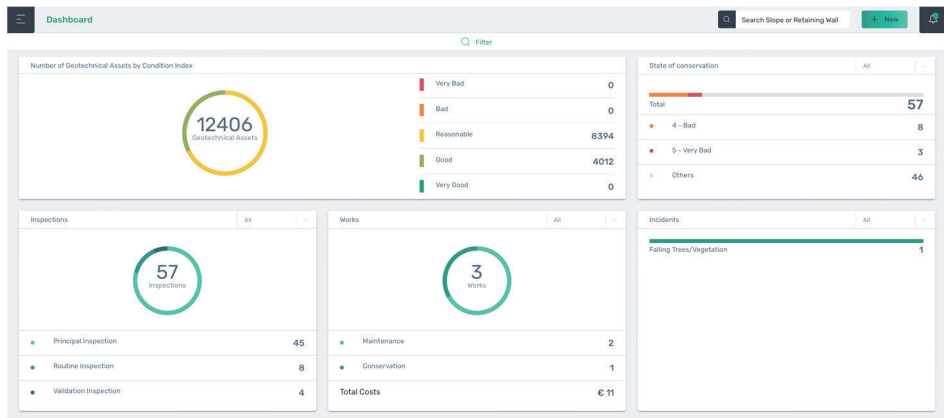


Figure 4 5-classe distribution of Brisa's network of geotechnical assets



Figure 5 Critical asset network of sensors

5 Conclusions

This study provides preliminary insights into the newly developed geotechnical asset management software, levelAMS, successfully implemented within Brisa's network. Beyond its core function of facilitating inventory management, the software stands out for its unique capability to classify assets based on their condition, utilizing the Condition Index developed by [2]. A notable advantage of the software is the centralization of all asset information within a unified platform, fostering seamless processes for inspections, work registrations, and incident recording. To comprehensively understand the full spectrum of benefits, additional inspection campaigns are deemed necessary. The software's potential for risk assessment is a significant advantage, particularly in the context of managing extensive asset networks. The platform's comprehensive mapping capability holds the promise of fostering a more strategic approach to short and long-term intervention planning. It provides the means to analyze the individual or macro-level condition evolution of slopes, contributing to more informed and rational decision-making processes in geotechnical asset management. This robust analytical framework not only enhances the efficiency of current operations but also lays the foundation for proactive and data-driven strategies in the management of geotechnical assets.

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