Safer Excavation for Safer Homes

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Maltese bedrock, while robust, contains fissures that pose significant risks during excavation, potentially compromising the structural stability of the excavation faces. Current geotechnical investigations rely on borehole cores, typically providing limited information about fissures. The cores are often disturbed or rotated, meaning the direction of the fissures cannot be reliably determined, so fissures can only be fully assessed when the excavation is complete. This is often too late to prevent the rock wedges from moving and causing damage to the overlying adjacent structures. ***Project RockSense****, a collaborative effort by the University of Malta and Solidbase Laboratory Ltd, introduces advanced technology to assess these fissures within the same boreholes that are normally drilled for investigative purposes. By enhancing excavation safety and informing new construction regulations, the team intends for their technology to restore community trust by reducing the risk of building damage and collapse.*

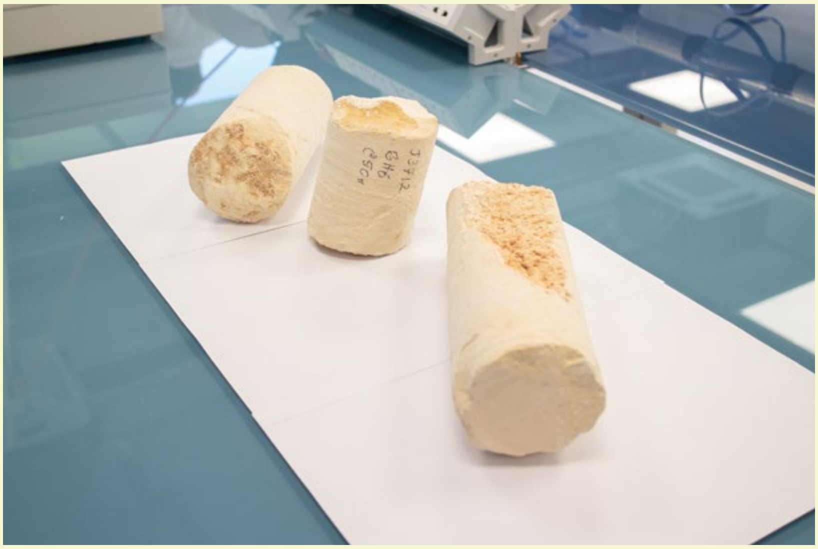
In recent years, Malta has experienced a number of deaths related to the construction industry. One-size-fits-all legislation that has more holes than Swiss cheese has resulted in loosely regulated demolition and excavation practices, fostering complacency and rampant risk-taking. Tragedies have spurred reform, but this is far from sufficient to ease the worries of homeowners. Having robust regulations and legislation is imperative, not only to prevent fatalities but also to ensure that adjacent property owners are not exposed to undue risk of incurring damage to their property. Standards are required to ensure health and safety and to safeguard the property of third parties, as applied in other EU nations, taking into account the peculiarities of the local ground conditions.

Maltese bedrock contains many fissures, or natural cracks, that vary in width, depth, and orientation, but it can still support the weight of most of our buildings. This should not be taken for granted, as this is only possible because of the lateral forces that create a confining effect on the rock, preventing the shifting of inherent wedges from fissures. Excavation can eliminate this lateral confinement, allowing the rock wedges beneath building foundations to move, leading to damage or outright loss of stability.

When excavation is required, Maltese law stipulates that a geotechnical ground study or investigation precedes this to identify the nature of the rock and possibly the presence of fissures. Traditionally, such studies consist of drilling a borehole into the ground, extracting the core, and assessing its various characteristics. However, the law does not define how wide or deep the borehole should be, nor the number of boreholes that must be drilled to survey different areas of the plot. Thus, filing proof of a geotechnical investigation with the Building and Construction Authority does not necessarily mean that a proper investigation has been conducted. Notwithstanding, even if a proper geotechnical investigation takes place, traditional methods still fall short of identifying the orientation and inclination of these all-important fissures.

WHAT IS RIGHT?

In a perfect world, architects, civil engineers, and contractors would have a precise understanding of the number, direction, and size of these fissures. However, inspecting them from within the excavation is too late to prevent cracks in the plastering, improper door closure, or loose tiles in the adjacent properties. This raises the question: Is this acceptable in the 21st century?



Top: The prototype of the RockSense downhole instrument

Top right: Electrical equipment used for field testing

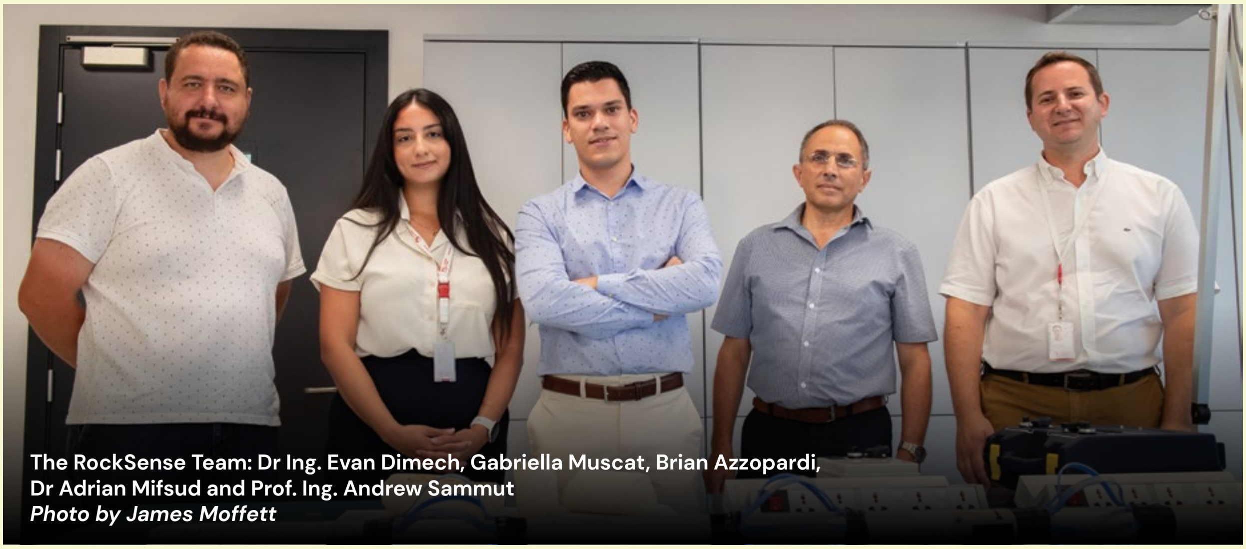
Left: Rock core samples extracted from boreholes

Photos by James Moffett

We can do much better, according to a group of engineers from the Department of Electronic Systems and the Department of Civil and Structural Engineering at the UM. This optimism is shared with one of the local ground investigation companies, Solidbase Laboratories Ltd, and collectively, they have taken it upon themselves to innovate and create new technology that allows safer, evidence-based excavation methodologies. Project RockSense aims to enhance traditional ground investigation, by considering less-obvious possibilities. Lecturer and geotechnical engineer Dr Adrian Mifsud shares, 'We asked ourselves, why not study the walls of the borehole itself instead of looking only at the core?'

Through a multidisciplinary collaboration between the aforementioned departments and Solidbase Laboratory Ltd., RockSense is developing cutting-edge technology that can assess the nature of borehole walls with the primary aim of collecting data on fissure orientation and fissure characteristics. For now, the team has used boreholes drilled at UM to emulate real-life use of their technology. Testing their prototype has yielded an initial data set, enabling the team to reconstruct the measured fissures in 3D.

The technology being developed by RockSense is composed of various subsystems, each with its own hardware and software components that aim to collect specific sets of data. The seamless integration of these components is crucial to ensure reliable operation in the field. Data collected from different subsystems and sensors must be combined through processes like sensor fusion and data processing to yield meaningful insights into the mechanics of rock fissures. Among these subsystems are imaging and 3D scanning technologies. Imaging is being utilised to visualise and record the borehole walls. Through innovative algorithms, these visuals will facilitate a more efficient and detailed assessment of fissures' size, location, width and infill. The scanning process, as coupled with established rock mass description techniques typically used in rock mechanics, has enabled a much more accurate representation of investigated rock masses before these are exposed by excavation. This approach not only enhances the safety of excavation practices but also sets the stage for more informed and evidence-based construction regulations.



The RockSense Team: Dr Ing. Evan Dimech, Gabriella Muscat, Brian Azzopardi, Dr Adrian Mifsud and Prof. Ing. Andrew Sammut
Photo by James Moffett

Collecting adequate and trustworthy data from construction sites requires reliable hardware, which is especially important given the unforgiving nature of such environments. To create such dependable technology, the RockSense team is utilising a mix of off-the-shelf components and custom-designed parts, optimising both cost and functionality. They are using various manufacturing methods while employing out-of-the-box thinking to create robust hardware capable of withstanding field conditions with commercially available components. As hardware development progresses, the team continues to refine their system, ensuring that all subsystems function reliably together.

TODAY'S FINDINGS SERVING TOMORROW

The research team hopes that with more data collection, they can push the boundaries of modelling rock masses. This data will allow them to develop mathematical models to determine the position and orientation of fissures in 3D space and better understand the mechanics behind them. Furthermore, the team is eager to maximise the opportunities created by the expected abundance of discontinuity data that RockSense is designed to generate. This will enable a better understanding of both geology and geomorphology, thus facilitating the development of country-specific legislative standards and informing new guidelines on site-specific excavation and construction practices.

By enabling and maximising best practices in ground investigations, RockSense aims to reduce the risk associated with excavation and provide a catalyst for sustained improvement and innovation in the industry. This will ultimately promote accountability among developers and foster a culture of safety across the construction sector, both locally and abroad. With reliable safety measures in place, the community's trust in ongoing and future construction practices can be restored, mitigating the anxiety associated with such practices. Ultimately, a stable living environment contributes to the overall well-being of residents, fostering a stronger sense of community and belonging. RockSense's contribution goes beyond technical advancement: it reinforces the essence of the home as a sanctuary, restoring the much-desired sense of safety and trust in Malta's urban landscape.