Formation design and investigation

- a picture is worth a thousand words

How do we communicate results of geotechnical investigation?

Constructing greenfield rail requires communication of complex ideas and concepts, inevitably with some loss of information along the way. Some of the most common sources of geotechnical information for greenfield rail projects include the results of geotechnical boreholes and test pits. One of the advantages of test pits is that they provide a much greater lateral extent 'window' into the conditions at a test location, exposing conditions with horizontal spread, not just vertical depth. It would be immensely useful for the project team to walk through the site while the test pits are open, particularly for earthworks in challenging soil types.

Photogrammetry has developed significantly over the last couple of decades, buoyed by improvements in digital camera hardware and software. It has been used to capture 3D models, digital elevation models and orthorectified images that can be used for accurate measurements.

- Adoption and provision of detailed photogrammetry models with the result of geotechnical investigation overcomes the following still photos limitations: It's often difficult to appreciate the scale, context, and orientation of detailed still photos
- Sidewall images are frequently only able to be captured from a single point of view from the upper crest of the test pit.
- This produces a 'parallax distortion' where detail visible in the image becomes more 'compressed' with depth.

Case study: Reinventing test pit imaging

Preliminary desk studies identified the likely presence of reactive soils along certain sections of the Inland Rail alignment. While the site investigation was planned and executed in accordance with AS 1726-2017 (the Australian Standard for Geotechnical Site Investigation), the standard has limited provisions for describing moisture-sensitive conditions in detail. Further, it provides limited guidance for how best to record and communicate such conditions.

The Inland Rail team recognised that valuable information could be lost if special effort wasn't in place to capture this detail. Ideally, the designers and specialists in interpreting signs of soil moisture reactivity would be on site for the excavation of each test pit, however the remote nature of the site made this impractical.

Macquarie Geotechnical have been commissioned to undertake site investigations for this portion of the alignment, and proposed a novel solution using photogrammetry techniques to capture the test pits in sub-millimetre 3D detail.

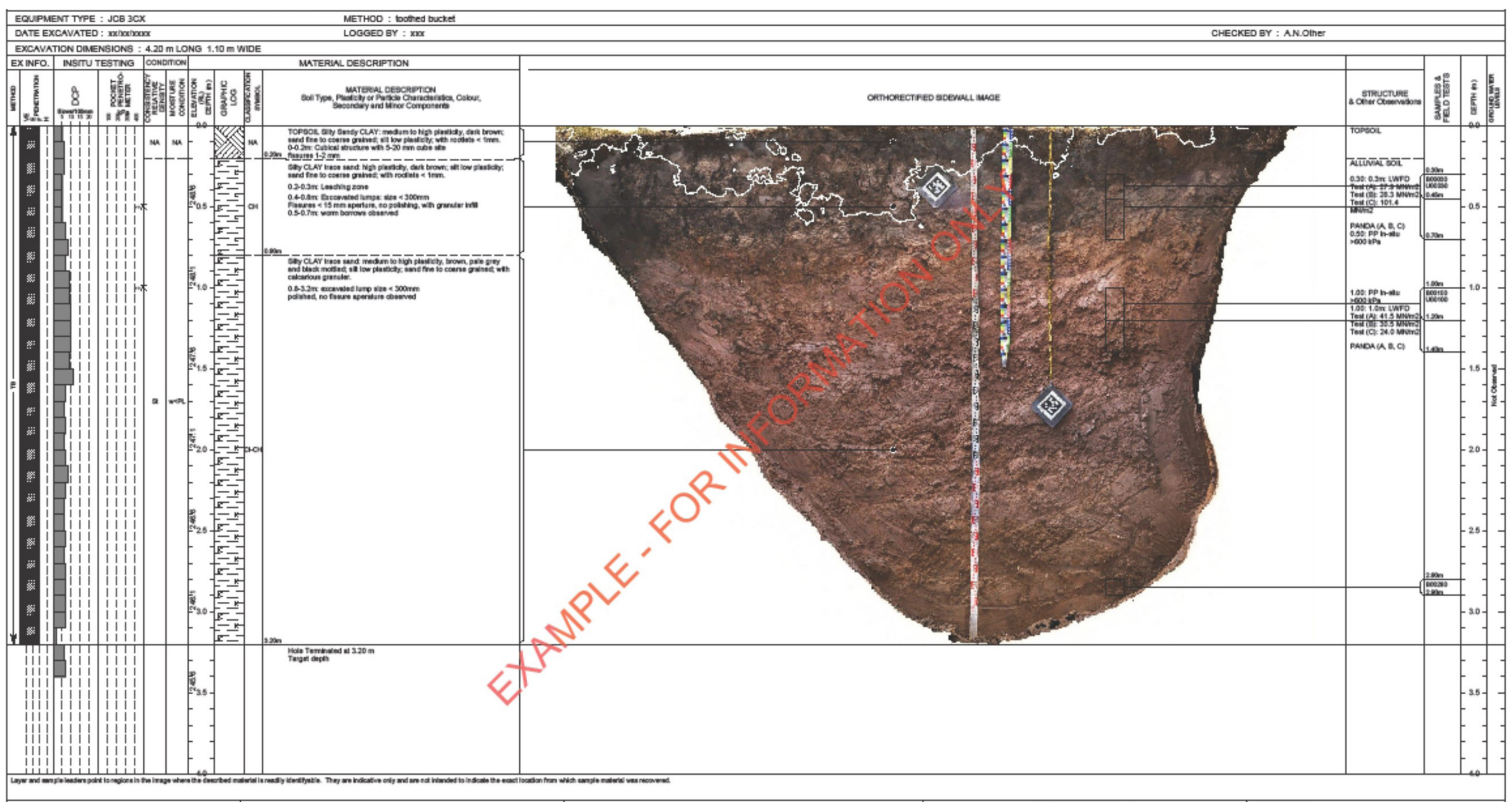
About test pit photogrammetry

Photogrammetry refers to a process through which 2D still images of physical objects are captured, aligned, and processed into 3D models. This practice is commonly used to process data from drone surveys.

Macquarie Geotechnical envisage equipping every field engineer's toolbox with the necessary knowledge and training to make photogrammetry-based deliverables BAU (where beneficial). In this case, the team were able to use terrestrial capture techniques to capture approximately 600 still images in and around the test pits. The images were processed using a tool with high emphasis on 3D photorealistic reconstruction.

Each model took approximately 6 hours to process and produced a measurable and georeferenced 3D model of each test pit and its surrounds, as well as an orthorectified image of one sidewall of the pit. The 3D models were made accessible to the Inland Rail team via a web map application from which all models were able to be viewed from the one map. The sidewall orthophotos were presented on a modified version of a standard test pit log. Some examples of the result can be seen on this poster.

Inspection of the models allows stakeholders to undertake 'virtual' inspection of the test pits, with the ability to measure exposed features, including crack aperture; depth and frequency/spacing; identification of precipitate nodules; infilling; evidence and scale of self-mulching; slickensides; and root persistence. Collaboration over the models in the early stages of the project helped align expectations of data users with practical constraints on data generators identifying features in the field.



Test pit photo

In a simple test pit photo (top), the level of detail visible in the image diminishes with depth.

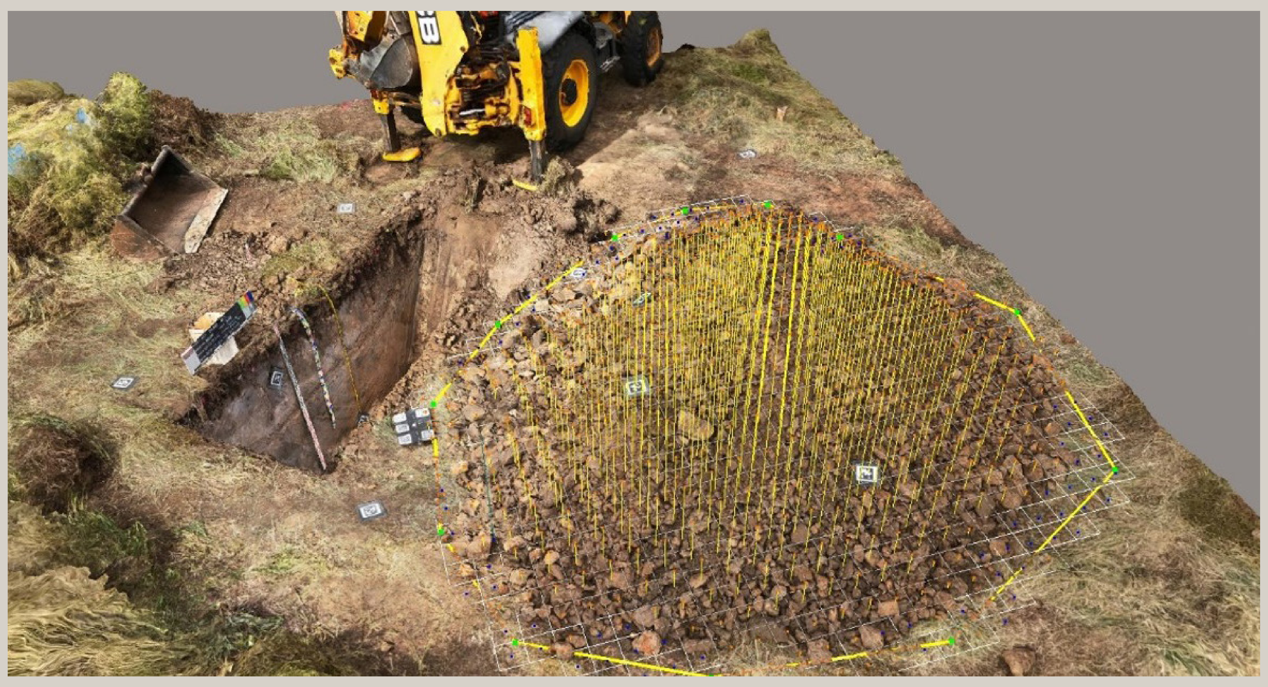
Orthorectified sidewall image

In an 'orthorectified' sidewall image (bottom) the entire sidewall is reprojected from an orthogonal perspective.

The scale and level of detail is constant throughout the entire image.

These models allow features to be viewed from any angle – even looking upwards from within a pit (top) and are fully georeferenced, allowing for linear, area, and volume measurements (bottom).

Scan the QR code to view a 3D model.



The Future

The use of 3D visualisations to communicate has become 'business as usual' in many areas of the Australian construction sector. At Inland Rail, these models are used to collaborate with both internal and external stakeholders. These test pit models have achieved considerable benefit in the design phase, however the models remain a possible resource that can be 'revisited' as the project progresses through detailed review, construction, performance review and maintenance stages. A particular strength of the product is that the models are georeferenced and can be viewed in one map, in real-world positionings, meaning users are able to access and benefit from the models without needing to be familiar with the site investigation program.

In conjunction with the presentation of photos and models that allow a 'remote' detailed review of the observed conditions, a consistent method for logging physical characteristics of black soil, such as type and nature of defects, likely infill and presence of organics, would augment conventional logging to AS1726. Visualising 3D design along with 3D below ground information to the project team is a picture worth more than a thousand words.

Authors

Andrew Doe, Principal Geotechnical Engineer, ARTC Inland Rail

Tim Swavley, Senior Geotechnical Engineer, Macquarie Geotechnical