Complex formations with a block-in-matrix fabric

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Complex formations with a block-in-matrix fabric

SUMMARY

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Summary

This Ph.D. thesis studies geotechnically complex formations with a block-in-matrix internal arrangement in order to better understand the technical difficulties associated with their identification, characterization and modeling and to provide possible solutions and tools to overcome these challenges. The complexity of these heterogeneous formations originates from the great variability in their structure, lithology and geotechnical properties. A large number of widespread geologic units, such as conglomerates, agglomerates, glacial tills, weathered rocks and, above all, melanges, belong to this category of complex formations.

The definitions, perspectives and classifications of such materials have been the subject of much debate and confusion among experts since the 1950's. In 1994 Edmund Medley coined the term "bimrock", the acronym for "block-in-matrix rocks", to conveniently denote the wide variety of heterogeneous formations composed of strong rock blocks embedded in a bonded matrix of finer texture. The great potential of this term was that it had no geological connotation, since it generically indicated all rock-soil mixtures. Nonetheless, inappropriate geologic definitions are still being used in the literature, engendering great confusion among geopractitioners and readers. Hence, the first objective of this Ph.D. research was to shed light on this nebulous terminology, by developing a clear classification for block-in-matrix complex formations.

Previous research has demonstrated that rock inclusions (their content, position, shape, etc.) strongly influence the overall mechanical behavior of heterogeneous geomaterials. Since the commonly used deterministic approaches cannot capture the inherent spatial and dimensional variability of these complex formations, a novel stochastic approach has been introduced in this research in order to investigate how rock inclusions may influence the stability and failure modes of bimrocks. Specifically, 2D and 3D numerical simulations were carried out on many slope and tunnel models with different block contents, dimensions, positions, shapes and orientations, highlighting the benefits of using such a statistically-based approach. Moreover, from an operative point of view, rock blocks and their characteristics strongly influence the choice of the most appropriate earthwork equipment and underground excavation and support methods. However, reliable estimates of block quantities and characteristics are not straightforward and constitute one of the

greatest challenges for geopractitioners.
Stereological principles are generally applied to infer 3D block contents from 1D or 2D measurements, but they are often fraught with a high magnitude of error. In order to provide information that may help to address the research gaps regarding this topic, two novel statistically-based tools, implemented in different Matlab codes, were developed in this research. The first investigates the degree of error that can be introduced by inferring the 3D block contents from 2D measurements, providing an uncertainty factor to adjust the initial estimates. The second was developed mainly for practical applications. In particular, the new proposed tool allows the probability of encountering blocks when tunneling in heterogeneous ground to be estimated and could help to reduce tunneling risks.
In order to explore and tackle the many difficulties inherent in the characterization of these geomaterials, a typical Italian melange from the Oltrepò Pavese area was thoroughly investigated. In particular, the efforts undertaken to collect and prepare intact specimens, which were mainly caused by its sensitivity to water, are described in detail, as are the laboratory tests, which often required non-conventional procedures. A series of triaxial tests were carried out with the aim of providing all the necessary information to set up and calibrate a 3D numerical model reproducing the laboratory tests. However, remolded specimens had to be used, since the different matrix properties and block characteristics (dimensions, lithologies, etc.) of the natural samples did not allow the tests to be performed under controlled and repeatable conditions. To obtain the real geometry of the specimens tested, X-ray Computed Tomographies were performed on the heterogeneous samples. Although the numerical model is beyond the scope of this research, it could be a valid tool to predict the mechanical behavior of geomaterials like the Oltrepò Pavese melange, but with different block contents, shapes and mechanical characteristics when subjected to various stress histories.