Discoverer's Report

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- **Date:** 20th of October 2024
- **HTC Contribution:**
TC 101 – Laboratory Testing
The pioneering work of Desrues et al. (1996) on the application of non-intrusive techniques such as Computed Tomography (CT), X-ray CT Scanning, and Acoustic Emission in geotechnical engineering.

1. **Summary:**

This report examines the pioneering work of Desrues et al. (1996) on the application of non-intrusive techniques, specifically computed tomography (CT), X-ray CT scanning, and acoustic emission, in geotechnical engineering. These advanced methods allow for the internal observation and analysis of soil and rock specimens without disrupting their natural state, providing valuable insights into their structural and mechanical behavior.

The authors investigated the internal structural changes in sand during triaxial compression tests using computed tomography (CT). They specifically focus on the evolution of void ratio within shear bands, which are localized zones of intense deformation. The study reveals that the void ratio within these shear bands increases significantly as the specimen is loaded, indicating dilation. This research provides valuable insights into the micro-mechanical behavior of sand under stress, highlighting the effectiveness of CT scanning in capturing detailed internal deformations.

Over the past 15 years, it has been recognizsed that strain localization affects most laboratory tests on soil specimens. In plane strain or biaxial tests, shear bands can be directly observed. However, in the common axisymmetric triaxial test, detecting and describing these patterns is more challenging. The distribution of void ratio during the test, particularly near the specimen's limit strength, is crucial for correctly interpreting volume change measurements. Often, stabilization of global volume change is considered an indication of reaching a critical state, but this interpretation is questioned if deformation is inhomogeneous.

This study explores the local evolution of void ratio as strain localization occurs. Historical insights from Casagrande & Watson (1938) suggest significant void ratio increases in shear zones during failure. Modern experimental tools and techniques, like computed tomography (CT), now allow detailed internal observations of strain localization in soils. CT scans provide quantitative density field data inside 3D sand specimens under mechanical loading, highlighting both local and global deformation behaviors.

2. **Why This Contribution Caught My Attention?**

The contribution caught my attention because of its *revolutionary approach* to studying soil mechanics using *non-invasive, high-resolution techniques*. Traditional soil testing methods often rely on external or global measurements that may miss localized phenomena, such as shear band formation, which are critical for understanding the failure and deformation of soils. By utilizing CT scanning, the authors were able to *visualise and quantify internal deformations*, offering unprecedented insights into how materials behave under stress. This *shift from external to internal observation* opens new avenues for more accurate prediction and analysis of soil and rock behavior in real-world geotechnical applications, such as construction, excavation, and slope stability.

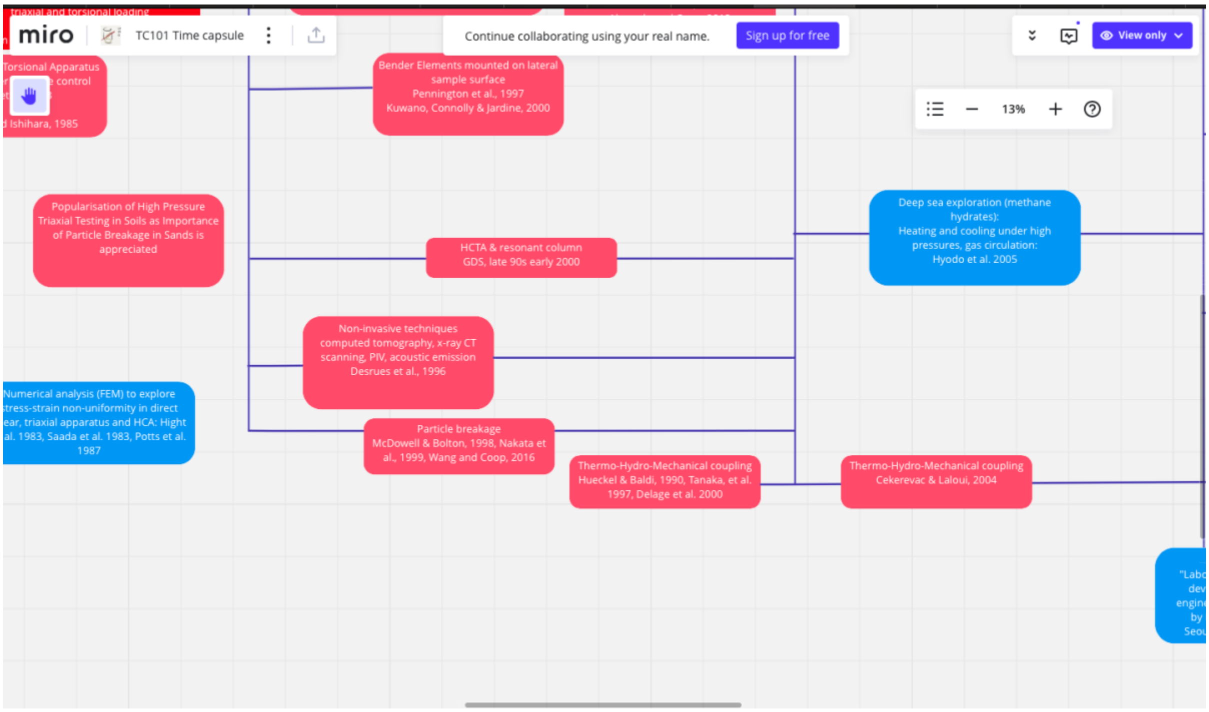
3. The Most Interesting Part of the Contribution

The most compelling aspect of this study is how it challenges traditional interpretations of soil behaviour under stress. Most geotechnical tests measure changes in void ratio on a global scale, often leading to the assumption that stabilisation of the void ratio signals that the soil has reached a critical state. However, Desrues et al. (1996) demonstrated that while global void ratio may stabilize, local void ratios within shear bands continue to evolve towards a distinct, consistent value.

This finding highlights the importance of localised measurements, suggesting that the critical state of a material may not be uniform throughout the sample. The use of CT scanning allowed the researchers to identify this phenomenon, which was previously difficult to detect. Understanding these localized changes could lead to more accurate predictions of failure in soils, especially in engineering projects where soil behavior is critical, such as in foundations, embankments, or retaining walls.

4. Expectations on the Future of the Geotechnical Community

- **Technological Integration:** As non-intrusive imaging techniques like CT scanning become more accessible, the geotechnical community could see a shift towards more data-driven, localised testing methods. This could result in more precise designs and safer infrastructure, particularly in projects involving complex soil behaviors, such as landslides, tunnelling, and earthquake-prone areas.
- **Data Analysis and AI:** The large datasets generated by these imaging techniques could be further enhanced by integrating artificial intelligence (AI) and machine learning algorithms to automatically detect patterns, anomalies, and potential failure points within soil structures. This could lead to more predictive and proactive approaches in geotechnical engineering, improving both safety and efficiency.
- **Sustainability and Material Efficiency:** Understanding the localised behavior of soils could also contribute to more sustainable engineering practices. By accurately predicting how materials will behave under load, engineers can avoid over-engineering solutions, thereby reducing the environmental footprint of construction projects through the optimal use of materials.



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Torsional Apparatus
Ishihara, 1985
Bender Elements mounted on lateral sample surface
Pennington et al., 1997
Kuwano, Connolly & Jardine, 2000
Popularisation of High Pressure Triaxial Testing in Soils as Importance of Particle Breakage in Sands is appreciated
HCTA & resonant column
GDS, late 90s early 2000
Deep sea exploration (methane hydrates):
Heating and cooling under high pressures, gas circulation:
Hyodo et al. 2005
Non-invasive techniques
computed tomography, x-ray CT scanning, PIV, acoustic emission
Desrues et al., 1996
Numerical analysis (FEM) to explore
stress-strain non-uniformity in direct
ear, triaxial apparatus and HCA: Hight
al. 1983, Saada et al. 1983, Potts et al.
1987
Particle breakage
McDowell & Bolton, 1998, Nakata et al., 1999, Wang and Coop, 2016
Thermo-Hydro-Mechanical coupling
Hueckel & Baldi, 1990, Tanaka, et al. 1997, Delage et al. 2000
Thermo-Hydro-Mechanical coupling
Cekerevac & Laloui, 2004