Forum: Steps to increase the reproducibility of geotechnical laboratory test data

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The ability to reproduce (or not) the experimental results of other researchers forms one of the key tenets of the scientific method. For many disciplines of science, where the materials tested can be derived from relatively basic chemical elements, or are of a common biological origin, it is possible for different research teams to obtain what is needed to carry out identical experiments to check reproducibility. Similarly, scientific methods that are based on numerical tools are amenable to checks by different researchers. Indeed, to this end, there is an increased prevalence for peer-reviewed geotechnical journals to include data availability statements, further increasing the likelihood of such sharing, the benefits of which were argued by Jefferies (2016).

Unlike some of the previous examples, geotechnical laboratory testing is an area where assessing reproducibility is difficult. Different soils and tailings are generally impossible to reproduce given their varying origins and mineralogy. While laboratory-standard materials offer some options for testing reproducibility, much of the work required in our field involves materials that are not commercially available. The first three authors were inspired to prepare this forum, and seek the involvement of others, because of a recent round robin exercise they led (Reid et al. 2021a), the results of which provided many learnings between laboratories. This built on a long history of round robin exercises in geotechnical laboratory testing (Yamashita et al. 2009, Toki et al. 1986, Tarantino et al. 2011), and examples such as that of Been et al. (1987) where sharing of material between laboratories led directly to the development of methods to interpret state parameter from the cone penetration test that were instrumental in most subsequent developments in this field (Shuttle and Jefferies 1998, Ghafghazi and Shuttle 2008, Shuttle and Jefferies 2016).

Future benefits of increased sharing of soils could include, but are certainly not limited to:

- Checks on experimental reproducibility, generally. There are a number of researchers carrying out testing that requires reconstitution using various methods, but quite limited comparison of how similar the outcomes of seemingly similar experimental procedures in different laboratories actually are. Increased sharing of material would assist in this area.

- Fabric studies to investigate different preparation methods. This has been an area of intense study and debate for decades (Vaid et al. 1999, Høeg et al. 2000, Chang et al, 2011, Reid and Fanni 2020), yet still lacking in consensus in many areas. As such, an ability for the work of one team to be expanded by another team who uses different approaches would be very useful.
- Further investigation by researchers on materials relevant to recent tailings storage facility (TSF) failures. While, to our knowledge, material cannot currently be obtained for research purposes from any of the major recent TSF failures, it is conceivable that this will change in the future. For example, recently published industry guidelines support the public sharing of data wherever possible (ICMM 2020), seemingly consistent with the philosophy of this forum. Given the intense interest in these failures and the finite timeframe available for the failure investigations, the ability of other researchers to later carry out further testing on the same materials would be of great benefit. An example of this in practice can be seen through the decades of study that followed the Lower San Fernando Dam (Castro et al. 1985, Castro et al. 1992, Baziar and Dobry 1995, Jefferies and Been 2006, Robertson 2010, Chowdhury et al. 2019), which present a rich library that has contributed much to our understanding and methods to assess liquefaction - activities that would often only be possible with free sharing of materials in a manner proposed by this forum
- A myriad of other interesting and currently studied aspects of soil behaviour, such as transitional behaviours (Coop 2015, Xu and Coop 2017), investigating the range of accessible laboratory densities compared to in situ states (Shuttle and Cunning 2007, Reid et al. 2018, Reid 2021), and different means to try to reproduce in situ bonding or structure (Schneider and Moss 2011, Robertson 2016, Robertson et al. 2019) could all benefit from additional studies that include checks on reproducibility.
- Research may have focussed on a particular or unusual test, for example calibration chamber studies of the CPT, with soil behaviour established by the researchers'

preference for, say, drained triaxial tests. However, if another framework evolves then that particular or unusual data can be given new life if testing for the new framework can be done on the originally used soils. An example of this was the study into unifying CPT calibrations by Been et al. (1987) where researchers from Ente Nazionale Energia Elettrica-Centro Ricerca Idraulica e Structturale, Norwegian Geotechnical Institute, Turin Polytechnic, and the Universities of Southampton, Berkeley, and Florida were all able to share samples of their reference soils for further testing to determine the respective critical state properties. A little additional laboratory testing then brought the very-expensive-to-redo chamber test data into new use – and that could not have been done without stockpiles of soils that could be shared.

The authors of this forum therefore advocate that those in the geotechnical testing community wherever possible consider whether their testing programs can be carried out in such a manner that sharing of the soil with other researchers is feasible. The main steps to accomplish this end would be recognition in the early stages of the work when preparing a bulk sample for testing was being carried out (i.e. by ensuring sufficient material is prepared and/or mixed) and a willingness to agree to such sharing. Some of the authors of this forum have themselves begun including the following wording in the data availability statements at the end of their laboratory publications (Reid and Fanni 2020, Reid et al, 2021b) whenever possible to promote such sharing:

The authors indicate that in the interests of enabling checks by other researchers as to the reproducibility of our results, and to build on the current work, untested material from this study can be made available to others upon reasonable request and provided sufficient material is still available.

While the authors of this forum intend on using such wording whenever possible in their work, should this become increasingly widespread in the geotechnical testing community a useful way forward would be for papers to include a “Material availability statement” similar to that now provided for electronic data in many leading journals. The requirement to

explicitly answer questions as to the availability of material in submissions would likely itself promote an increase in planning and allowance for sharing by geotechnical testers.

DATA AVAILABILITY STATEMENT

No data, models, or code were generated or used during the study.

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