Common ground between soil scientists and geotechnical engineers

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Abstract

There is an emerging lack in Australia of science graduates with significant studies in soil science. Traditionally the rolls of soil scientist and geotechnical engineer have been kept separate in the work place. However, as graduate soil scientists become fewer (there are no soil science degrees available in Australia), there is a need to encourage geotechnical engineers, geologists and environmental scientists towards the more traditional soil science areas. There is increased demand for a range of studies, including acid sulfate soils, carbon sequestration initiatives, soil contamination, salinity impacts etc., with a focus on sustainability and environmental responsibility, as well as the more traditional engineering properties. There is high demand in all areas of soil science to address sustainable and environmentally defendable development, as well as investigation of basic soil properties. Incorporation of as many aspects of soil/land characterisation into investigations for projects covering large areas and varied soil landscapes (such as corridor studies, mining leases etc.) and some on the job training becomes logical and cost effective. This presentation aims to compare requirements for soils and engineering investigations and highlight options for educating and training of staff.

Key Words

Chemistry – Training – Stratigraphy – Characterisation – Sampling – Groundwater.

Introduction

As a point of clarification, this paper is not ‘technical’ in nature, it does not present the findings of any specific research, rather observations made in a professional environment over the past 15-20 years. As a senior scientist and engineer in a large engineering consultancy, I and many others in my field, both geotechnical engineers and soil scientists, currently lament the lack of graduates from soil science based university courses as the demands for environmental soils investigations increase.

The Problem

In fact, other than one or two agricultural science degrees and a single diploma level soils technology/science course, there are no soil science degrees being run by universities in Australia. In addition, many engineering courses have dropped soil units from their syllabuses; the argument over the past decade being that high school graduates have lacked the maths and science basics to handle too many science units, and so these are kept to the bare minimum (unfortunately in our field a sound knowledge of soils is ‘the bare minimum’). As a result of fewer soils course options there has been a considerable lack of new soil scientists joining the work force over the last 10-15 years. This has occurred at the same time as a reduction in the number of people in allied fields with sound soils knowledge, due to retirements in an aging participating workforce and some redundancies in government agencies. The average age of soil Australian scientists has been estimated at over 55 years of age. This combined with the re-emergent economy, a boom in infrastructure, and increased demand on agriculture is resulting in a higher than ever demand in all areas of soil science. However, there are fewer qualified people available to do the work, including Government employees (i.e. regulators). Additionally, people in positions to pass on some of the key soils knowledge (private and Government sectors) are busier than ever, so on the job training by these people is problematic.

Similarities (and Differences) Between Engineering, Environmental and Agricultural Soil Studies

Engineers have been studying soil properties and it’s interaction with structures for as long as soil scientists and agronomists have been studying soil chemistry and biology and the interaction between soil, groundwater, plants and the receiving environment.

There is a lot of common ground with what scientists and engineers need to know about soils and how to use the knowledge. Summarised in Table 1 are areas of soil investigation and assessment, relevant to both soils scientists and geotechnical engineers.

Table 1. Similarities and Differences in the Soils Field Investigations

Area of Interest	Relevance to Engineers	Relevance to Soil Scientists
Origins of soils and their eventual fate	2	3
Ways of "classifying" soils, to allow common interpretation	3	3
Mapping / Displaying soil type and data	2	2
Moisture state and it's relationship to soil properties	3	2
Soil chemistry – effecting soil behaviour	2	2
Soil chemistry – effecting agriculture/vegetation	1	3
Environmental Impact – caused by disturbing soil/water system	2	3
Erosion Control in Agriculture and/or Construction	2	3
Influence of contaminates soils – costs, constraints	3	2
Use/Disposal of soils in engineering, mining and construction	2	1
Total	22	24

Note: Where '3' is most important (note this is based on observation and is somewhat subjective)

It is easy to see that scientists and engineers often have similar information priorities in most of their requirements for soils knowledge. So it seems very reasonable to pool what resources are available when undertaking soil assessments and where possible to create accessible soils databases. The latter has become more easily achievable with the advent of powerful, inexpensive data storages and high speed and portable internet connections. Sometimes clients and planners fail to recognise commonalities in the various investigation programs that are commissioned for projects, particularly as more varied high level assessments become mandatory for development. This is particularly so [in Australia] where different government agencies are responsible for different aspects of the approvals process.

In practice, many scientific investigations tend to target one or more specific areas and may be undertaken as part of data gathering or mapping exercises such as, mapping Acid Sulfate Soils, Dry Land Salinity, Good Quality Agricultural Land, Soil landscapes etc. However, a good deal of the data gathered for each of these discrete exercises can be of use to the others. For example, cations and anions (and associated ratios such as CEC and ESP), pH, EC, soil moisture and particle size are common to many investigations, and screening for metals, common nutrients and organic matter (organic carbon) are also useful in several circumstances. Some aspects of contaminated land, agricultural and geotechnical investigations are more specific, but can still be assessed from the same boreholes or test pits.

The origin of soils, whether they are imported fill (unknown origin), alluvial, colluvial or formed *insitu* as weathering products of underlying parent geology can be of great importance. Assessing soil chemistry and how the soils may act if disturbed (i.e. whether are they are acid forming, potentially dispersive, saline, potentially contaminated etc.) and interaction with groundwater through watertable influences and water quality impacts should be undertaken using an holistic approach. The data accumulated can then be used for a number of related purposes.

Typically scientific investigations specify undisturbed soil samples or a continuous 'core' to be recovered for both logging and sampling purposes, while geotechnical investigations require *insitu* strength tests, typically at set intervals down the borehole with recovery of both disturbed and undisturbed samples from locations between the strength testing locations. For most applications, a selection of representative disturbed and undisturbed samples will suffice for chemical testing even where physical tests may need to be undertaken on the same samples, as only small representative sub-samples are required for most soil chemistry analyses. Even geotechnical programs utilising 'wash boring' techniques which do not recover soil between the intermittent sampling intervals can be used for preliminary and indicative assessments of soil chemistry where only a single sample from each soil horizon is sufficient.

Some investigations, such as those for Acid Sulfate Soils require continuous sampling in order to capture accurately the stratigraphy present in an alluvial sequence, however, this becomes less important when sampling from disturbed soil profiles. Sampling for contaminants, is generally focused on the source of contamination and may focus on the fill materials, surface soils, former natural surface, alluvial channels where present or perhaps the interface with shallow parent rock.
Soil sampling from disturbed or homogenous sources (e.g. stockpiles) should be random and based on an adopted frequency such as one sample/50m^3.

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Characterising large areas is often undertaken by sampling on an area basis (e.g. 1 location / 4ha) or may target individual land forms such as ridges or depressions, or along the banks of waterways; or within specific soil landscapes.

Sample collection and preservation is important. Samples for chemical or biological analysis usually require collects in clean jars, sometimes with preservatives added, and require being kept refrigerated and dispatched promptly to laboratories within relatively short holding times. Engineering samples generally requires less attention, but some need to be undisturbed so are taken as block samples sealed in wax, or using thin walled metal tubes of common diameters (U50, U75 etc.) which need to be sealed at both ends to preserve moisture state for testing. Regardless, all samples need to be clearly identified, dated and documented on borelog records and laboratory chain of custody documents. This is common to all soils investigations. Marking, either physically with stakes and tags, or using a coordinate system, usually both is also very important, as data that cannot be attributed to specific locations is often useless. All of these techniques and processes form a vital part of the fieldwork for both scientists and engineers, and adequate training must be provided.

A Way Forward

A way to rectify the situation, at least in the short to medium term is to encourage cross learning and skilling among geotechnical engineers and environmental science graduates. This could be achieved by the inclusion of soil science subjects in core and elective streams of engineering, and a stronger focus on soils properties and chemistry and groundwater interaction, in environmental science courses. While geotechnical engineers typically take four or more soil and rock mechanics subjects as well as basic geology, there is typically only a single core ‘environmental’ subject, which broadly covers aspects of soil, water, air, flora and fauna.

There would be great benefit from including a specific soil chemistry subject dealing with the importance of soil chemistry and highlighting the interrelationship with engineering soil properties and the way that engineers and scientists classify and log soils. A better understanding of soil and groundwater interaction is also needed to allow soil assessments to predict changes in the groundwater system and potential impacts.

A brief introductory syllabus covering the basics of sodic/ dispersive soils, acid forming soils, contaminated soils, soil salinity and soil nutrients and properties that benefit agriculture would be very useful. Similarly, a better understanding of soil chemistry and how this interacts with physical properties (i.e. erosion and stability, expansive clay soils, aggression to built structures and the potential to cause environmental impacts), would greatly improve the engineering graduates knowledge base.

In-house training within the major engineering firms based around technical presentations and workshops and on the job where environmentalists and engineers present case studies and investigation methods to each other can benefit all. Particularly when flexibility within the workforce is such an axiom of the modern approach to staffing.

It is important to ‘think outside of the square’ when preparing proposals and planning site investigations. The pairing of experienced engineers with graduate environmental scientists for investigation programs that are predominantly engineering in nature, and the reverse for soil science studies and environmental programs with limited engineering requirements, would allow good governance while promoting learning across the disciplines. Training of engineers in basics of soils science and utilising flexible sampling and data gathering methods makes it is possible to obtain a wider range of environmental and geotechnical information from one sampling program. This needs to be considered when preparing proposals for large scale investigations such as ‘broad brush’ area and corridor investigations for feasibility studies and Environmental Impact Statements, where a range of developmental constraints need to be considered.

A summary of proposed lecture topics/course content that could form the basis of possible soils subjects aimed at combining environmental, agricultural and engineering input is given in Table 2.

Table 2. Suggested inclusions in a 'Soils & Engineering' subject suitable for either syllabus

Suggested 2 Hour Sessions	Composition
Origins of Soils their fate.	Basic geology Lithology Transport mechanisms.
Classifying Soils to Allow Common Description and Understanding	Classification (Australian Soils Classification Vs USC Systems) Soil profile descriptions (horizons, strata, weathering fronts etc.) Practical aspects of soil logging (texture, colour, moisture etc.) What else is needed on a soil log ? location, date, co-ordinates description of samples recovered, refusal on rock etc.
Mapping and Describing Soils & Landscapes	Soil distribution / landscapes Use of GIS systems Availability of published data (maps, test data and web-sites) Types of assessment – ASS, Erosion Potential, GQAL, Salinity
Moisture Related Soil Properties of Clays, Silts, Sands and Gravels	Moisture state and retention (practical) Soil consistency (practical) Influence on insitu strength Compaction characteristics of soils Permeability and void saturation state Clay shrink/swell characteristics.
Hydrogeology and Soils	Micro Vs macro permeability The water table / deep drainage influences Effluent disposal / irrigation practises Salinity migration Catchment hydrogeology/groundwater.
Chemistry Influencing Soil Behaviour	Soil sodicity and salinity Soil Nutrients Acid Sulfate Soils Contaminated soils
Soil Science for Agriculture	Nutrient retention and loss Soil biology (biota) Impacts of pesticides Maximising crop yield
Erosion and Soil Conservation	Erosion and Sediment Control (ESC) assessment Erosion measures for agriculture ESC Plans for construction and infrastructure Dispersive soils – use of lime and gypsum and geotextile
Use of Soils in Mining and Construction	Managing mine tailings Open cut planning Construction of temporary roads Rehabilitation planning measures.
Soils for Cropping and Farm Maintenance.	Aeration and mechanical impedance Maximising crop yield Topsoil retention Draining of Acid Sulfate Soils (impacts).

Conclusions

A number of short courses have been conducted by ASSSI (in Queensland) over the past two decades, and while these have been well attended and very successful and are to be applauded, it is not enough and the private sector must try to assist wherever possible. Private sector engineering firms, can act to provide some course presenters and 'one off' or periodic workshops outside of the formal education system. Consideration should also be given to running a mentoring program for junior scientists and engineers by allied organisations like ASSSI and Engineers Australia, possibly utilising retired persons who retain a wealth of knowledge, some of which will otherwise disappear as it has failed to cross the void into cyber space.

In closing, it is hoped that this paper has summarised the many commonalities between the needs of soil scientists and engineers (and clients and other stakeholders); and highlighted some of the short falls of the current tertiary education system and workplace training in Australia. It is hoped that this may focus some in the industry who are best placed to assist in promoting the spread of soil science education and practise.

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