Andrew Schofield Disturbed Soil Mechanics Re-visited: 2nd Edition in 2018: With Excellent Forewords by Prof. Mark Randolph & Prof. Lord Mair

[Just a Brief Background of how I ran into this interesting subject: I was awarded the Government University Scholarship in 1963 based on the Final Examination performance in Engineering at the University of Ceylon. I went to see Dr. Thurairajah at Peradeniya and seeked his advice. He agreed to help me to find my way to Cambridge and made sure I don't change my mind. There you are I got a place at Cambridge in late Prof. Roscoe's Soil Mechanics group. Roscoe moved up from Lecturer to reader and Reader to Professor in 1967.

I spent little over three years at Cambridge from August 1965 at February 1969. For a person who seems to have managed well in examinations with class room notes, it was a great agony to read the three papers at Cambridge: Roscoe Schofield & Wroth 1958, Roscoe & Poorooshasb 1963 and Roscoe Schofield & Thurairajah 1963. I made hand written notes from these papers; Roscoe seem to have been impressed with these notes; at least this is what he told me. Originally I intended to work on X-rays and Gamma Rays and gradually shifted to Critical State Soil Mechanics. That explains having Dr. Jimmy James as advisor. I was always very nervous about research.

I used to stupidly argue with Prof. Schofield and when I finished my thesis, Roscoe asked me about the Examiners. I suggested Prof. Andrew Schofield.

Then I spent a year at NGI with Dr. Elmo Dibiagio a truly remarkable instrumentalist and a great mentor. Then I returned to Sri Lanka and joined the Engineering Faculty at Peradeniya, where Prof. Thurairajah was building a great Soil Mechanics Group. I saw an excellent group at AIT headed by Dr. Za Chieh Moh and moved to AIT in November 1973 as an Assistant Professor. I stayed at AIT till June 2001 and retired at the age of sixty. I then spent a year at the Nanyang Technological University in Singapore. Returned to Brisbane Australia to join my family who migrated there in 1992. I joined the Griffith University in 2002 July and am still with Griffith as an Adjunct Professor.

Currently, I spent all my time as the Editor in Chief of our SEAGS-AGSSEA Journal. I virtually guided and help this journal since 1973 or so. I was the Secretary of SEAGS for the whole period I spent at AIT. Since 2011, we had excellent Issues of this Journal. There were many Journal Issues in the name of distinguished personalities. I have asked Prof. Schofield too to have one under his name.]

My journey at a glance: Both with Disturbed and undisturbed (or least disturbed) Soil mechanics




In chronological order: Sri Lanka with Thurairajah; Cambridge with Prof. Roscoe; NGI with Elmo Dibiagio & Finally with AIT with Dr. Moh

1. *Prof. Andrew Schofield - TRUE ACADEMIC: AT 90 still working on Disturbed SOIL MECHANICS*

Prof. Schofield at AIT

I (Bala) always learn a lot from Andrew who has now a second edition of his book on Disturbed Soil Behaviour

The first version is over 30 MB; my computer refuses to accept as attachment
The Table of Contents of the second edition is included here. The first edition has more or less the same Table of contents.

Chapter 1. ***Slip plane properties: Introduction; Coulomb's theory of strength; Masonry in Coulomb's essay; Soil Properties in Coulomb's essay; Recent Thinking of Ground as an Aggregate of Grains; Liquefaction and Critical State; Coulomb's Law***

Chapter 2. ***Interlocking Critical States (CS) and Liquefaction: An Interlocking Soil Strength Component; Frictional Dissipation of Energy and The CS; Reynold's Dilatancy and Hazen's Liquefied Soil; Herrick's Liquefaction; Failure at Low Effective Stresses***

Chapter 3. ***Soil Classification and Strength: Casagrande's Soil Classification and Soil Plasticity; Variation of Strength with Water Content; Hvorslev's Clay Strength Data and The CS Line of Clay; CS Interpretation of Hvorslev's Shear Box Data***

Chapter 4. ***Limiting Stress States and CS: Strain Circle; Soil Stiffness and Strength; Rankine's Soil Mechanics; From the Plasticity of Steel Frames to Plastic Strain in Soils; Skempton's Parameters A and B, and CS Values of C and Phi***

Chapter 5. ***Plasticity and original Cam Clay: Baker's plastic design of steel frames; The associated flow rule and Drucker's stability criterion; Thurairajah's power dissipation function; The OCC yield locus; Test data, model modification design; Design for deformation and mobilisable strength design; Laboratory testing and geotechnical design***

Chapter 6. Geotechnical Plastic Design: The Place of Plastic Analysis in Design; Lessons from The Geotechnical Centrifuge; Herrick's Liquefaction in Models; Geotechnical Centrifuge Developments; Solving Industry's Problems; Conclusions

2. Biography: Andrew Schofield & Stuart Haigh from Revised Edition in 2018:

Prof. Schofield at AIT

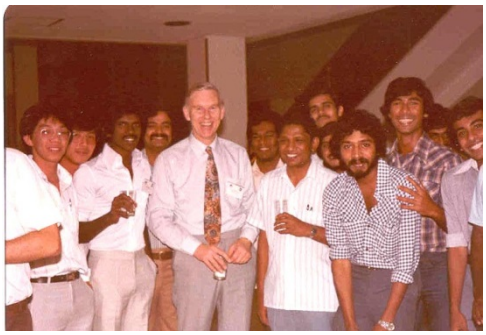
Andrew Schofield FR ENG, FRS is a soil mechanics engineer and Emeritus Professor of geotechnical engineering at the University of Cambridge. Andrew studied engineering and graduated from Christ's College Cambridge in 1951.After a period in Malawi researching in lateritic soils, and low cost construction he returned to Cambridge University to work with Professor Kenneth Harry H Roscoe on his Ph D which he completed in 1961.He became an Assistant Lecturer in 1961 and was elected Fellow of Churchill College, Cambridge in 1964.

Andrew returned to Cambridge in 1974and was appointed as a professor in the Cambridge University Engineering Department to lead the Soil Mechanics group. Working with a mechanical design engineer Philip Turner, he developed a 5m radius geotechnical centrifuge at Cambridge University that continues to be used.

In 1993, on the joint nomination of the President of the Institution of Civil Engineers (ICE) and the Royal Society, the ICE awarded Andrew the James Alfred Ewing Gold Medal for special meritorious contributions to the science of engineering in the field of research. He has been awarded the US Army Distinguished Civilian Services Award. More recently, he was the recipient of the Royal Academy of Engineering Sir Frank Whittle Medal in recognition of sustained achievement throughout his career.
Andrew retired from the university in 1997, but his continued work is evidenced by his involvement in the Schofield Centre for Geotechnical and Environmental Research.

Co-author Stuart Haigh of the 2018 revised edition is ***Stuart Haigh*** M Eng, PhD is a university Senior Lecturer at the University of Cambridge, the Assistant Director at the Schofield Centre for Geotechnical Process and Construction Modelling and has been involved in the field of geotechnical engineering for over 20 years. Stuart obtained his BA, MA, MENG and PhD in Geotechnical Engineering from the University of Cambridge and has extensive experience using centrifuge geotechnical centrifuge modelling to investigate a wide array of research problems, ranging from liquefaction of slopes during earthquake to the long term behaviour of foundations for offshore wind turbines. He (Stuart Haigh) has published more than 100 journal and conference papers and was a member of the Geotechnique Advisory Panel from 2012 to 2015.

3. Foreword to the First Edition by Prof. Mark Randolph



Prof. Mark Randolph at AIT; Prof. Peter Wroth at AIT

In my final year as an undergraduate at Oxford University, I undertook a project on the warping of asymmetrical steel beams with Dr. Edgar Lightfoot. I took no formal lectures on soil mechanics, although Dr. Lightfoot also gave a few lectures on slip lines and bearing capacity within an optional “specialty” paper on civil engineering. He also gave me career advice along the lines that “there is this new theory called critical state soil mechanics, which seems to be worth investigating. I duly bought a copy of Schofield and Wroth’s (1968) book on that subject, and so began my education in soil mechanics. I subsequently studied for my PhD with Professor Peter Wroth, and cut my teeth as a lecturer at Cambridge University in the group then headed by Prof. Andrew Schofield. It is therefore with humility, and a sense of the wheel having turned full circle, that I myself writing a foreword to this “retrospective” new book by Andrew; indeed, I have a sense of being under examination, wondering what grade my former professor will assign.

Much of this book describes the developments leading to the original Cam Clay model, focussing on fundamentals of the shearing of soil. The aim is to lay the ground work of understanding that should form the basis of geotechnical design, guiding engineers towards the class of behaviour to be expected under different combinations of effective stress and water content. There are a few equations, but simple ones; much greater challenge rests in the arguments put forward regarding soil behaviour and the intellectual effort needed to keep pace with the author. After the special lecture that he (Prof. Schofield) delivered at the 2001 International Society of Soil Mechanics and Geotechnical Engineering in Istanbul, he commented that it was “heard without comprehension”. The lack of comprehension was not to do with the complexity of concepts or algebra, but with grasping the underlying message and appreciating that many experienced academic and practising engineers do indeed have, and the misleading language and teaching that pervades much education in soil mechanics.

The book is divided into six chapters, which progress from the simple planar siding of soil towards plastic design in geotechnical engineering. But Andrew Schofield is not constrained by sequence, and rather than write a conventional textbook, he had in mind the sort of book “engineers might read on a flight and leave on their coffee tables”. The coffee table image came from a reviewer of the proposed book, perhaps meant as disparaging, but is excellent advice here; the book *invites* reading at a single sitting, both because it is intensely interesting, and because of author’s global approach, with much cross referencing – across the centuries as well as between chapters. After reading, it is a book to be left readily available for frequent dipping, both for the pleasure in the historical anecdotes spread across the last 400 years and to reinforce the fundamental understanding of soil behaviour conveyed in the book.

The frontispiece illustration is the lynch-pin to the ideas the author wishes to convey, and is referred to throughout this book. Heroes (Coulomb, Hvorslev, and Taylor) and villains (Terzaghi in particular) are identified in Chapter 1, with detailed discussion of the nature of friction, the role of interlocking and the misinterpretation of Hvorslev’s empirical envelope of peak strengths as indicating true cohesion. The second chapter focusses on the critical state, correcting Casagrande’s critical void ratio to allow for the effective stress level, and liquefaction , contrasting extreme forms related to ultra-high void ratio, or to near – zero effective stress. Historical anecdotes replace the usual glossy pictures of a coffee table book.

There are frequent (positive) quotations from Terzaghi’s writings in the literature, but inevitably for someone to fond of dogma it is not difficult to find negative examples. His assertions of cohesive bonding between soil grains, and rejection of the usefulness of Rankine’s limiting stress states, are two such

examples that are discussed at some length in Chapters 3 and 4. In defence of his (c, phi) strength model, Terzaghi did advocate that clay should be tested 'under condition of pressure and drainage similar to those under which the shear failure is likely to occur in the field'. However, that caveat seems to have been overlooked and, even today, the (c, phi) strength model is taught widely and used inappropriately. Current teaching is littered with calculations where the effective stress differs significantly from the conditions under the c-phi fit were derived. Modern teaching often applies such a model to bearing capacity analyses on sand, without adjustment for the resulting high stresses, or to the stability of slopes and cuts, where pore pressure dissipation would destroy any apparent c. Students who understand soil strength according to Andrew's approach is wise to these dangers. A modest ambition for the present book might be to see the words 'cohesion' and 'adhesion' excised from our soil mechanics vocabulary, replacing them with respectively 'shear strength' (at a given water content and effective stress level) and, on the rather rare occasions where it is appropriate, 'cementation'. The basis of the original Cam Clay model, including its background in the theory of plasticity and the experimental evidence for the internal plastic work, is described in Chapter 5. Limitations of this simple model in terms of anisotropy, soil sensitivity and cyclic loading are readily acknowledged. As a basic framework for teaching, however, the model still has much to offer, and it's refreshing to be taken through the careful experimental data on reconstituted clays on which it is based, and (now classic) examination questions from the Cambridge Tripos of nearly 40 years ago. Once armed with the simple concept of wet and dry of the critical state line, students will understand whether a sample will wish to contract or dilate , whether pore pressures generated during undrained shearing will tend to the positive or negative , and conditions where ductile plastic deformation might change to brittleness and fracture. The ability of the model to quantify these states is immediately appealing to modern students, rather than them having to digest purely qualitative explanations.

Andrew Schofield deserves to be regarded as one of the geniuses of soil mechanics of the latter half of the 20th century. His Fellowships of the Royal Society is based on two remarkable contributions of original Cam Clay and the promulgation of centrifuge modelling in geotechnical engineering beyond its origin in Russia. It is appropriate, therefore, that the final chapter in this book is devoted to the application of the principles of critical state soil mechanics by means of centrifuge experiments conducted under conditions of stress similitude.

This is a rewarding book, full of insights, bot technical and personal. It reinforces ideas described in the original Schofield and Wroth book *Critical State Soil Mechanics* and in Schofield's 1980 Rankine Lecture. For the unconverted, it is an invitation to re-examine your basic understanding of soil behaviour. For the converted who might be tempted to dismiss the book too lightly, it is a call to ensure that our teaching and the vocabulary and nomenclature we use in describing strength models for soil, reflect accurately the underlying concepts.

Prof. Mark F Randolph,
The University of Western Australia

Foreword to the second edition by Professor Lord Robert Mair

Professor Lord Mair at AIT

This second edition of an excellent book explaining critical state soil mechanics (CSSM) and geotechnical centrifuge model testing contains a considerable amount of new material of great interest to civil and geotechnical engineers. Much of this is a fascinating odyssey through many of the seminal

engineering contributions in the past that have led to the key theories of shear strength, plasticity and CSSM.

On shear strength the reader is taken through the exploits of Marshall Vauban (1633 -1707), who built many forts to defend France and formed the army engineers corps (Corps Royal du Genie) to assist in the attack and defence of forts with earth-retaining structures. This led to Coulomb's experience of construction of similar fortifications as a young French Royal Engineer and to him proposing his famous equations to compute the stability of Vauban's defences. The book continues with interesting descriptions of how Amontons (1699) had proposed that interlocking caused friction, and much later of how Taylor (1948) in his seminal work found experimentally that ultimate steady friction and interlocking must be summed to give the peak strength on slip planes in dense sand. We read of Reynolds describing dilation of sand in his famous rubber balloon demonstrations in 1902 and of Casagrande later introducing the concept of the critical void ratio in the context of flow slides, liquefaction and the failure of the Fort Peck Dam. All of this, combined with the powerful concepts of plasticity, is nicely brought together to explain the thinking behind the unified theory of the original Cam Clay model and of CSSM. The book also has new additions relating to recently published work on liquid and plastic limits and strength variation with water content.

Plastic design is an essential part of a well-grounded engineering education. Just as the upper- and lower – bound theories of plasticity allow the behaviour of structures to be bounded, plastic design is no less important to geotechnical engineering. This edition illustrates this very well and has also expanded the sections on centrifuge modelling to reflect recent developments. It bring outs the message that simple constitutive analysis based on CSSM, notably Bolton's mobilistic strength design (MSD), complimented by centrifuge modelling gives a route to effective safe design. It illustrates how geotechnical engineers can study ductile or brittle failures using model tests on soil under appropriate stress levels using a geotechnical centrifuge. Most importantly, it shows how such model tests can inform engineers of failure and deformation mechanisms that might not have otherwise been evident. The probable mechanism of collapse of an already completed tunnel in Hull in 1999 was uniquely explained by a series of centrifuge model tests.

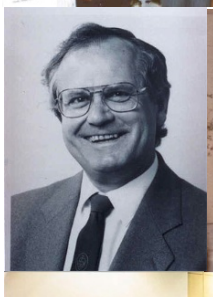
Tunnelling and excavation ground movement and mechanisms obtained from centrifuge tests have had a seminal influence on the design and construction of urban tunnelling schemes around the world, particularly in relation to the prediction and control of settlements by new techniques such as compensation grouting.

Whether it be on such diverse topics as the behaviour of foundations of offshore structures under storm loading, the effects of earthquake and liquefaction, or the understanding of tunnelling through soils under high stresses, the excellent second edition illustrates the myriad of opportunities for civil engineers to gain important insights from the powerful concepts of CSSM and geotechnical centrifuge testing. The book is also a wonderful tribute to Professor Andrew Schofield – a visionary civil engineer whose research in soil mechanics and geotechnical engineering has been transformational.

Professor Lord Robert Mair
President, Institution of Civil Engineers, 2017-2018

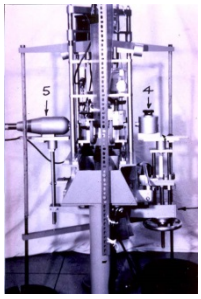
ALL AND PLENTY MORE IN MY ARCHIVE AT AIT







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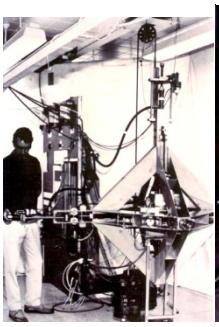

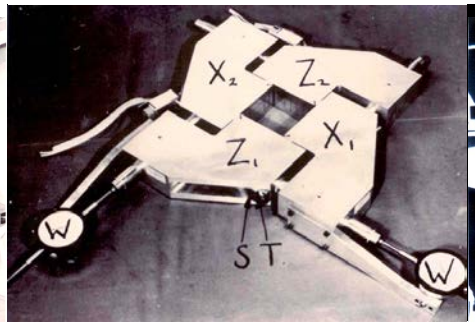
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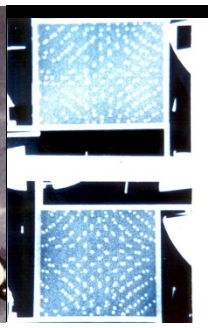


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