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PhD Theses: 2010

The purpose of these summaries is to bring to the notice of readers topics in geotechnical engineering that are currently or have recently been subjects of research at universities in the United Kingdom. The summaries are arranged in alphabetical order, first by university, and then by surname.

M. Valls-Marquez, University of Birmingham, UK
Evaluating the capabilities of some constitutive models in reproducing the experimental behaviour of stiff clay subjected to tunnelling stress paths

This thesis evaluates the capabilities of four constitutive models in reproducing the behaviour of stiff clay when subject to tunnelling-induced stress paths. Relevant stress paths were determined from 2D and 3D finite-element analysis using PLAXIS, and reconstituted Speswhite Koalin clay specimens were prepared from a slurry and tested using state-of-the-art stress-path equipment. The soil model testing software SM2D was used to compare the numerical predictions to the experimental measurements. The results showed that there are still many limitations in terms of accurately modelling the response of overconsolidated clay, particularly at small strains and when subject to extension.

Sponsor: University of Birmingham

Contacts: Dr D. Chapman, Dr G. Ghataora and Professor A. Chan

U. Cilingir, University of Cambridge, UK
Seismic response of tunnels

This dissertation presents the methods and the results of an investigation aimed at discovering the soil–structure interaction of tunnels during earthquakes. The focus has been on shallow and flexible tunnels in loose dry sand. Dynamic centrifuge tests have been conducted on small-scale tunnel models. These small-scale models were constructed at different flexibilities, shapes and embedment depths. Soil and lining deformations were recorded using a fast camera. These deformations were measured using particle image velocimetry (PIV) technique. In addition, complementary finite-element (FE) analyses have been carried out using a general purpose FE code.

Sponsor: Yuskel Proje

Contact: Dr G. Madabhushi

M. Liska, University of Cambridge, UK
Properties and applications of reactive magnesia cements in porous blocks

Reactive magnesium oxide (MgO), and blends of MgO and Portland cement (PC), were studied as a more sustainable alternative to PC for applications in porous masonry blocks. Their fundamental properties and subsequent applications were investigated through their physical, mechanical, hydraulic, chemical, durability and microstructural properties. It was found that in porous blocks and under the appropriate curing conditions, MgO hydrated and then rapidly fully carbonated, by absorbing significant quantities of carbon dioxide, resulting in significantly higher strength, up to 200%, than that of corresponding PC blocks. Successful, scaled-up commercial production of the blocks confirmed the enhanced technical performance and sustainability advantages.

Sponsors: EPSRC, University of Cambridge Domestic Research Studentship, Cambridge European Trust, Douglas Bomford Trust and City of Ostrava, Czech Republic.

Contact: Dr A. Al-Tabbaa

A. Marshall, University of Cambridge, UK
Tunnelling in sand and its effect on pipelines and piles

Three areas of research are dealt with: (i) tunnelling in sandy ground, (ii) tunnelling beneath pipelines, and (iii) tunnelling beneath piles. A series of centrifuge tests was carried out for each topic. Tests were carried out behind the face of a transparent Perspex® wall such that high-quality soil and structure deformation data could be obtained using an image-based measurement system. Test series (i) of tunnels in sand served as a baseline for comparison for the subsequent series of tests. The effects of soil–structure interaction on tunnel-induced ground displacements and pipe/pile response were evaluated in test series (ii) and (iii).

Sponsors: The Cambridge Commonwealth Trust, Kenneth Sutherland Memorial Scholarship (supported in part by Jesus College, Cambridge), ORS, NSERC, also BTS Research Award, Newby Trust Research Grant

Contact: Professor R. Mair

P. Nikolopoulos, University of Cambridge, UK
Mass transfer in non-aqueous phase liquid contaminated heterogeneous porous media

The entrapment of DNAPLs in natural soils exhibits complex morphologies, which generates uncertainty both in the prediction of heterogeneity effect on the mass flux produced by their dissolution and in the effect of soil structure on their fate and transport. Experimental investigation on the effect of dual-permeability structure on dissolution, fate and transport of tetrachloroethylene was conducted on natural and artificial physical dual permeability models. Analytical models were formulated for the calculation of mass flux from a single NAPL source. Field-scale heterogeneity effect on DNAPL source zone dissolution was examined by performing numerical simulations of DNAPL spill and dissolution.

Sponsor: BBSRC

Contact: Professor K. Soga

I. Pal, University of Cambridge, UK
Rainfall trends in India and their impact on soil erosion and land management

The research work involved the analysis of rainfall data in India and the prediction and assessment of long-term future trends and their impacts on soil erosion and associated contaminant transport leading to proposals for topsoil management practices to protect soil quality. This was performed

using historical rainfall data from 50–135 years and extreme temperature data for 103 years analysed for various aspects of Indian climate using suitable statistical techniques. The research work highlighted the importance of climatological analysis at local decision-making level, which is very useful for broad scenarios like climatological and ecological risk management.

Sponsors: Cambridge Commonwealth Trust Scholarship and Overseas Research Student Award

Contact: Dr A. Al-Tabbaa

P. J. Vardon, Cardiff University, UK

A three-dimensional numerical investigation of the thermo-hydro-mechanical behaviour of a large-scale prototype repository

This thesis describes the modelling of the thermo-hydro-mechanical (THM) behaviour of a large-scale experiment, known as the 'prototype repository project' and carried out at SKB's underground research laboratory in Äspö, Sweden. An existing THM model was extended to accommodate 3D behaviour, including the development of a high-performance computing algorithm. Simulations of the pre-placement stage and the post-placement operational phase were able to reproduce the experimentally observed highly anisotropic flow conditions. It was concluded that the geological conditions, backfill re-saturation and buffer re-saturation, including the micro-structural effects of the bentonite, are all important to the simulation of a high-level waste repository.

Sponsor: EPSRC and Cardiff University

Contacts: Professor H. R. Thomas, Dr P. J. Cleall

L. B. Qerimi, City University London, UK

Geotechnical centrifuge model testing for pile foundation reuse

The research was related to the problem of the reuse of foundations in congested urban sites a sustainable and cost-effective approach to the provision of building foundations. Centrifuge model testing was used to investigate how existing bored pile foundations in overconsolidated clay are likely to behave when unloaded due to demolition and then subsequently reloaded if reused for the new development. The influence of new foundations on the existing foundations is also described. The model tests include comparison of the behaviour of bored piles when supplemented with mini-piles of different length, number and spacing.

Sponsor: EPSRC, Cementation Skanska

Contact: Dr A. M. McNamara

L. J. Seward, City University London, UK

The effect of continuous flight auger pile installation on the soil–pile interface in the Mercia Mudstone Group

The project examined the soil-pile interface of continuous flight auger piles installed into the Mercia Mudstone Group in order to investigate the reasons behind some poorly performing piles installed in this Group. Four piles were installed with varying water content and over-rotation of the auger, and subsequently the upper section of each pile was exhumed with the surrounding soil. It was found that a distinctive remoulded zone had built up around all four piles, and this zone was tested using microscopy (SEM and thin section), physical (index tests and water contents) and chemical (XRD, ICP) techniques.

Sponsor: Stent Foundations

Contact: Professor S. E. Stallebrass

M. L. Schuster, Clemson University, USA

Framework for the fully probabilistic analysis of excavation-induced serviceability damage to buildings in soft clays

In this thesis, a framework for a fully probabilistic analysis of the potential for excavation-induced building serviceability damage in soft clays is established. The analysis framework is established with a serviceability limit state where resistance represents a building's capacity to resist serviceability damage, and loading represents the demand on a building from excavation-induced ground movements. In this study, both the resistance and loading are treated as a random variable; resistance is characterised empirically with a database of observed building performance while loading is estimated for specific cases using semi-empirical models developed using the results of finite-element analysis and field observations.

Sponsor: Clemson University

Contact: C.-H. Juang

A. Bezuijen, Delft University of Technology, The Netherlands

Compensation grouting in sand: experiments, field experiences and mechanisms

This thesis reports experimental research and field measurements on compensation grouting in sand. It describes laboratory tests in which it is investigated how grout bodies made during injection depend on the grout properties, the density of the sand and the way the tubes are installed. Thirty-four tests are reported in four different tests series. The shape of the grout body affects the injection pressure and whether heave is localised to one injection point or distributed over a wider area. An analytical model describes the relation between soil properties, injection pressure and shape of the grout bodies.

Sponsors: Deltares, Delft Cluster, North/South Line Amsterdam

Contact: Professor A. F. van Tol and Professor J. W. Bosch

J. Dijkstra, Delft University of Technology, The Netherlands

On the modelling of pile installation

This thesis introduces two different types of physical model tests to investigate the stress and density change in the soil during installation of a jacked pile. The first test method combines photo-elasticity (stress) with image correlation (strain) techniques in a plane strain 1g setup. The second test method measures the change in density of the saturated sand adjacent to the pile, during installation in a geotechnical centrifuge, with on the pile embedded apparent resistivity sensors. Additionally, two numerical modelling approaches using a finite-element code capable of large deformations have been presented to model these tests on pile installation.

Sponsor: Delft Cluster

Contact: Professor A. F. van Tol and Dr W. Broere

H. Sahar, Ecole des Ponts ParisTech, France

Fully coupled thermo-hydro-mechanical analysis of soil–vegetation–atmosphere interaction

A two-dimensional numerical approach is used to study the effect of soil–vegetation–atmosphere interactions and tree roots' water uptake on the thermo-hydro-mechanical

(THM) response of unsaturated swelling–shrinking clayey soils. The model uses meteorological data, soil THM characteristics and vegetation parameters to predict the soil water content variations and the resulted settlements. The model is implemented in a coupled THM finite-element code (θ-stock) and is verified based on the field measurements. This approach is applied successfully to study the effect of drought, especially the effect of isolated trees on building foundation settlements.

Sponsor: Ecole des ponts ParisTech BRGM

Contact: Professor C. Yu-Jun and Professor G. Behrouz

E. Saurer, ETH Zurich, Switzerland

Shear band propagation in soils and dynamics of tsunamigenic landslides

Conventional geotechnical methods to analyse the failure mechanisms of submerged slides tend to underestimate the real height of the resulting tsunami wave. Via physical tests an analytical model has been validated which provides an approach to calculate initial landslide velocity of submerged landslides and justifies larger tsunami wave-height predictions. The analytical model is based on the phenomenon of progressive and catastrophic shear band propagation in soils and on the energy balance approach from fracture mechanics. In order to validate this model, the rate of the progressive shear band propagation has been studied using physical trapdoor- and shear-blade tests and compared to the analytical solution.

Sponsor: Swiss National Science Foundation

Contact: Professor Dr A. M. Puzrin and Professor Dr D. M. Potts

H. Shin, Georgia Institute of Technology, USA

Development of discontinuities in granular media

Discontinuous planes often develop in soils; examples include shear bands, desiccation cracks, polygonal faults, and hydraulic fractures. These discontinuities affect the mechanical behaviour and transport properties of sediments. Contrary to discontinuities in solid materials, granular materials such as soils are already separated at the particle scale. Therefore, the fundamental understanding of the development of discontinuities in soils must recognise their inherent granular nature and effective-stress-dependent behaviour. This research focuses on particle-scale mechanisms involved in contraction-driven shear failure due to mineral dissolution, desiccation cracks, and hydraulic fractures. Complementary experimental, analytical and numerical methods are used to study three cases.

Sponsors: Goizueta Foundation, U.S. Department of Energy

Contact: Professor J. C. Santamarina

J. Li, The Hong Kong University of Science and Technology, P. R. China

Field experimental study and numerical simulation of seepage in saturated/unsaturated cracked soil

Cracks are prevalent in natural and engineered soils and provide preferential pathways for fluid flow and contaminant transport. First, comprehensive field tests were performed to characterise the development, pattern and geometry of cracks in soils, and the influence of cracks on the hydraulic properties of soils. Then, a mathematical model and a computer code are developed to simulate water flow through saturated random crack networks. Finally, a method is proposed to predict the soil water characteristic curve (SWCC) and permeability function for an unsaturated cracked soil considering crack volume changes during drying–wetting cycles.

Sponsor: Research Grants Council of the HKSAR

Contact: Professor L. Zhang

X. Li, The Hong Kong University of Science and Technology, P. R. China

Dual-porosity structure and bimodal hydraulic property functions for unsaturated coarse granular soils

Colluvial soils are often widely graded with high gravel contents and fines contents. This research focuses on the hydraulic properties and the microstructures of such widely graded coarse soils. Two advanced devices were developed and used to measure the hydraulic properties of five soils with different coarse contents. A typical bimodal feature is found in the SWCCs and the permeability functions for colluvial soils with high coarse fractions. For soils with high fines contents, unimodal SWCCs and permeability functions are common. The measured microstructures demonstrate that colluvial soil with a high coarse fraction ($>$70%) forms a coarse-controlled structure and colluvial soil with a high fines content ($>$30%) forms a fines-controlled, dual-porosity structure during compaction, which evolves into an intra-aggregate pore structure (unimodal pore size distribution) after saturation and shows significant shrinkage during drying.

Sponsor: The Hong Kong University of Science and Technology

Contact: Dr L. M. Zhang

G. Aldama-Bustos, Imperial College London, UK

An exploratory study of parameter sensitivity, representation of results and extensions of PSHA: case study – United Arab Emirates

Some confusion and misunderstanding exists regarding how probabilistic seismic hazard analyses (PSHA) should be conducted and interpreted. Hence commonly misunderstood aspects of PSHA, and new developments, are investigated. A comprehensive case-study PSHA for three cities in the UAE is carried out. While contradictory views of the hazard exist, the results support the view of low hazard-levels (UBC97, Zone 0) that increase towards the north (UBC97, Zone 1). The sensitivity of estimates to inputs such as: minimum magnitude source activity parameters alternative ground-motion models and allocation of logic-tree weights are investigated. The implications of employing alternative disaggregation strategies are also considered.

Sponsor: self-funded

Contact: Professor J. J. Bommer, Dr P. J. Stafford and Dr C. H. Fenton

D. Barreto, Imperial College London, UK

Numerical and experimental investigation into the behaviour of granular materials under generalised stress states

This thesis reports the results of discrete-element method (DEM) simulations of the behaviour of granular materials under generalised stress states. These simulations are compared to physical experiments on glass ballotini. Drained-hollow-cylinder tests have been performed in order to evaluate the effect of the intermediate stress ratio and the orientation of the principal stresses on soil behaviour. New algorithms were developed in order to include controlled

principal stress rotation in the DEM simulations. The results indicate a qualitative agreement between experiments and simulations. Micro-mechanical results demonstrate that the intermediate principal stress and the direction of the major principal stress have a significant influence on the stability of the contact force networks developed to sustain generalised stress states and mobilise anisotropic shear strength. Furthermore, it is shown that these phenomena can be explained via the evolution of soil structure (fabric).

Sponsor: EPSRC

Contact: Dr C. O'Sullivan and Dr L. Zdravkovic

I. Cavarretta, Imperial College London, UK

The influence of particle characteristics on the engineering behaviour of granular materials

This research considers the influence of the mechanical and geometrical properties of the particles in a granular material on the overall mechanical response. A new approach for the shape analysis of granular materials is proposed. Two new apparatuses were designed and commissioned to measure particle strength and contact stiffness and interparticle friction. In uniaxial compression tests an initial displacement level was identified before which the contact response is plastic. Beyond this plastic displacement the particles behave elastically until the final brittle collapse (crushing). Numerical simulations of the uniaxial compression test are described and a new contact model is proposed. In a series of triaxial tests, shape and roughness were found to affect the mechanical response of specimens of glass beads in terms of compressibility, stiffness and strength.

Sponsor: self-funded

Contact: Professor M. Coop and Dr C. O'Sullivan

B. Munwar Basha, Indian Institute of Science, Bangalore, India

Optimum design of retaining structures under static and seismic conditions: a reliability-based approach

Static and seismic design of retaining structures depend upon the load which is transferred from backfill soil, earthquake loading, external loads and resisting capacity of the structure. The traditional safety factor approach does not address the variability of soils, characteristics of the earthquake loading and external loads. Therefore the associated variability influences the design decisions considerably. A rational
procedure for the design of retaining structures is presented using the reliability-based design optimisation, considering the variability associated with the design variables. Performance-based design of gravity retaining walls when subjected to sinusoidal nature of earthquake loading is also presented.

Sponsor: Ministry of Human Resource Development (MHRD), India

Contact: Dr G. L. S. Babu

A. Hasan, Louisiana State University, Baton Rouge, USA

Micro characterisation of deformations in granular materials during shear

The dissertation presents a thorough characterisation of deformations in sheared granular materials. Two types of material were used F-75 Ottawa sand and Johnson Space Center (JSC-1A) lunar regolith simulant. The experimental programme utilised computed tomography (CT) technique and distinct-element method (DEM). The investigation was conducted at multi-scale (macroscopic, mesoscopic, and microscopic) to better understand the physical properties and constitutive behaviour of granular materials during shear. Results include particle micro characterisation, spatial void ratio distributions, measurement of shear band thickness, elucidation of localisation phenomenon, particle contacts, fabric evolution and development of stress–dilatancy empirical models.

Sponsors: Louisiana Space Consortium, National Science Foundation, NASA Marshall Space Flight Center

Contact: Dr K. Alshibli

D. J. Baxter, Loughborough University, UK

Innovation in the design of continuous flight auger and bored displacement piles

This project sought to optimise pile design through better understanding and interpretation of ground conditions and of the pile–soil interaction for continuous flight auger and bored displacement piles. Quantitative methods for interpreting and summarising previous knowledge and experience have been developed. A tool has been provided for the implementation of the approach into design, with previous knowledge and new site-specific data combined using Bayesian updating. Reduced uncertainty associated with interpreting ground conditions from site data has been demonstrated. To aid analysis of the probability of failure of a pile, the sources of variation have been investigated and quantified.

Sponsors: EPSRC, Rock and Alluvium Ltd

Contact: Professor N. Dixon and Dr P. Fleming

N. M. Cristelo, Newcastle University, UK

Deep soft soil improvement by alkaline activation

There is significant financial and environmental cost of producing Portland cement. This thesis describes the use of alkaline activation of a silica/alumina amorphous source (fly ash) to improve soils in situations where cement or lime/cement would be used. A laboratory programme was carried out, revealing strength improvements up to 11, 17 and 43 MPa, at 28, 90 and 365 days curing. The best source/activator combinations were chosen for field trials using jet grouting techniques, where they performed better than cement and adequately to pass standard engineering specifications. The main conclusion is the proven potential of alkaline activation in soil improvement.

Sponsor: Mota-Engil Group

Contact: Dr S. Glendinning and Dr Â. Teixeira Pinto

G. Della Vecchia, Politecnico di Milano, Italy

Coupled hydro-mechanical behaviour of compacted clayey soils

The thesis aims at improving the understanding of the behaviour of compacted clays, accounting for the evolving microstructural state of the soil and the coupled hydro-mechanical stress history. The work combines experimental and constitutive aspects. Laboratory tests and microstructural investigation are performed on compacted Boom clay, to study the evolution of water retention properties and stress-strain behaviour. A coupled hydro-mechanical constitutive model is proposed, in which fabric evolution, anisotropy and clay activity are accounted for in the evolution laws of the internal variables. In this way a simpler formulation results compared to those requiring an explicit double structure model.

Sponsor: none
Contact: Professor C. Jommi and Professor E. E. Romero Morales

A. R. Bhandari, University of Southampton, UK
The mechanics of an unbonded locked sand at low effective stresses

A digital image-based deformation measurement system for triaxial tests was developed and used to determine the instant and distribution of localisations in a naturally locked sand tested at effective cell pressures from 12·5 kPa to 100 kPa. Comparative tests on intact and reconstituted specimens confirmed the important effect of interlocked fabric structure on the strength and deformation behaviour. It allows the mobilisation of stress ratios close to peak before the onset of dilation, and increases the shear modulus at a given cell pressure and strain. Localisation was found to start at or after the onset of dilation, delayed at increasing confining pressures. Deformation was more localised at low cell pressures. Apparent differences between critical-state angles of effective shearing resistance of intact and pluviated specimens were resolved by considering the post-rupture kinematics.

Sponsor: EPSRC, ORSAS and University of Southampton
Contact: Professor W. Powrie and Professor D. J. Richards

M. T. Bui, University of Southampton, UK
Influence of some particle characteristics on the small strain response of granular materials

The effects of particle characteristics on the dynamic small strain response of soils were investigated. Particle shape significantly influences the small strain response of geomaterials. Both particle form and particle roundness correlate with G_{max} normalised by void ratio function. Normalised G_{max} increases with increasing sphericity and roundness of the particle. At the same void ratio, the stress exponent, n, elastic threshold strain, and shear modulus degradation, G/G_{max}, for granular materials decrease with increasing sphericity and roundness. Material damping ratio increases with increasing sphericity and roundness. The effect of resonant-column apparatus compliance on measured shear modulus was modelled, and a method of correction proposed.

Sponsor: Ministry of Education and Training, Vietnam
Contact: Professor C. R. I. Clayton and Dr J. A. Priest

S. D. Clarke, University of Sheffield, UK
Enhancement of the BRICK constitutive model to incorporate viscous soil behaviour

This thesis presents a framework for the numerical modelling of viscous effects in clays, including both time-dependent effects (creep and stress relaxation) and strain-rate-dependent effects. This framework has been incorporated into the BRICK soil model, allowing a series of realistic simulations of laboratory tests and, through implementation in a finite-element program, back-analyses of two case histories. These analyses show that introducing viscous effects into an already advanced constitutive model results in better predictions of both the rapid formation of a settlement trough due to tunnelling and the long-term heave of a deep basement.

Sponsor: EPSRC DTA
Contact: Dr C. Hird

F. Cecinato, University of Southampton, UK
The role of frictional heating in the development of catastrophic landslides

A thermo-mechanical model for the catastrophic collapse of large landslides is developed, considering thermal pressurisation of the slip zone due to frictional heating. The model is then applied to two well-known large landslides, a rotational (Vajont) and a translational one (Jiufengershan). Sensitivity analyses show that, although friction softening is the mechanism most affecting the timescale of final collapse, thermal pressurisation can lead to catastrophic failure even in the absence of any softening, depending on soil permeability and slide thickness. It is also shown that thermal pressurisation will cause thicker slides to accelerate faster, counter to intuition but in line with geological evidence.

Sponsor: EPSRC, grant EP/C520556/1
Contact: Dr A. Zervos and Professor W. Powrie

Q. Iqbal, University of Southampton, UK
The performance of diaphragm-type cellular cofferdams

Cellular cofferdam design guidance has been largely derived from the analysis and measured performance of interlocking circular cellular cofferdams. The validity of the common failure mechanisms associated with these structures when applied to diaphragm-type cellular structures was assessed by numerical analyses using FLAC and validated through field monitoring results from large-scale cofferdam temporary works associated with the construction of a pumping station at St Germans, Norfolk. Modified log spiral failure planes were identified. The monitoring revealed the extreme sensitivity of the structure to small changes in cell water levels and the importance of dewatering measures.

Sponsor: Costain Engineering Services
Contact: Professor D. J. Richards and Professor W. Powrie

E. V. L. Rees, University of Southampton, UK
Methane gas hydrate morphology and its effect on the stiffness and damping of some sediments

Methane hydrate was formed in sands under a variety of conditions, and the influence of hydrate morphology on stiffness was investigated using the gas hydrate resonant-column apparatus. Further tests were carried out to observe the effect of particle size and shape on hydrate bonding. High-pressure cores from the Indian National Gas Hydrate Program (NGHP) 01 were tested. CT imaging showed large volumes of sheet-like methane hydrate. The hydrate was dissociated and geotechnical tests were undertaken on the host sediment. Results from these tests suggest that hydrate dissociation will significantly affect host sediment strength and stiffness.

Sponsor: Fugro Ltd, Geotek Ltd
Contact: Dr J. A. Priest and Professor C. R. I. Clayton

M. Z. Zielinski, University of Strathclyde, UK
Influence of desiccation fissuring on the stability of flood embankments

The aim of the thesis was to investigate the influence of desiccation fissuring on the stability of flood embankments. In particular, the main objectives of this thesis are as follows. 1. Survey of flood embankments in UK constructed from clay fill to determine the extent and nature of desiccation fissuring. 2. Construction and investigation of the behaviour of macro-scale embankment model subjected to desiccation processes. 3. Investigation of the water-retention

behaviour of embankment model during drying–wetting cycles. 4. Investigation of the innovative, non-invasive geophysical technique for desiccation cracking detection. 5. Investigation of the embankment model behaviour under different flooding conditions.

Sponsor: FRMRC 1

Contact: Dr P. Sentenac

M. Nuth, Swiss Federal Institute of Technology Lausanne, EPFL, Switzerland

Constitutive modelling of unsaturated soils with hydro-geomechanical couplings

The thesis aims at formulating a new, fully coupled constitutive model for unsaturated soils, accounting for complex cross-effects between deformation and water retention. The dramatic, plastic strains and saturation changes are targeted for modelling. The effective stress concept for unsaturated soils is reviewed and clarified. An advanced model with multiple plastic mechanisms is adapted to unsaturated soils. The main features of the model are the built-in capillary effects, the capillary hysteresis and the retention curve for deformable media. The framework is applied to the modelling of earth dams and landslides, requiring the implementation of the model into Lagamine finite-element code.

Sponsor: Swiss Competence Center Environment and Sustainability, CCES, TRAMM Project

Contact: Professor L. Laloui

A.-J. Li, The University of Western Australia

Two- and three-dimensional stability analyses for soil and rock slopes

In this thesis, the results of a comprehensive numerical study into the failure mechanisms of soil and rock slopes are presented. The aim of this research is to better understand slope failure mechanisms and to develop rigorous stability chart solutions that can be used by design engineers. The study is unique in that two distinctly different numerical methods have been used in tandem to determine the ultimate stability of slopes, namely the upper and lower bound theorems of limit analysis and the displacement finite element method. The limit equilibrium method is also employed for comparison purposes. A comparison of the results from each technique provides an opportunity to validate the findings and gives a rigorous evaluation of slope stability.

Sponsor: Australian Research Council

Contact: Dr R. S. Merifield, Dr A. V. Lyamin and Professor M. J. Cassidy