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British PhD Theses: 2006

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.

Details comprising author, thesis title and a brief summary (not to exceed 100 words), of doctoral theses published in 2007 should be submitted to Mrs Kathleen Hollow, Editorial Coordinator, Géotechnique, Institution of Civil Engineers, 1 Heron Quay, London E14 4JD by 31 January 2008.

The summaries are arranged in alphabetical order, first by university, and then by surname.

A. Zolfaghari, University of Bath
Analytic and probabilistic landslide hazard assessment using GIS

A sophisticated probabilistic landslide hazard/susceptibility assessment within a GIS framework is proposed. Four computer programs such as SlopeSGA (2D slope stability analysis using SGA), GISRisk (probabilistic seismic hazard assessment), GISWaterRisk (3D groundwater change assessment), SoilGIS (3D soil layers property estimation tool) were written in VB.6. Using Monte-Carlo simulation, probabilistic landslide hazard/susceptibility maps are proposed which provide information on probability, location, and frequency of future landslide events due to earthquake loading, soil property uncertainties, and groundwater change for large scale area. A probabilistic landslide hazard map for the south-east of city of Bath (UK) as a study area was presented.

Sponsored by University of Bath studentship, teaching assistantship, University of Bath International Scholarship

Contact: Dr. Andrew Heath

B. Burns, University of Birmingham
Internal erosion of earth embankments

A laboratory investigation was undertaken to study the rate of internal erosion of soil using a modified pin-hole apparatus that included using a miniature resistivity array. Large piping tests on (0·8m cube) undisturbed samples showed that a pipe could lead to block failure. Clayey soils were seen to have a critical time and flow rate when accelerated rate of erosion was observed. Degree of saturation also had an effect on the erosion resistance of a soil and when soil was dried back, a critical moisture content was observed where the soil changed from non-dispersive to dispersive.

Contact: Dr G. S. Ghataora

C. Liaki, University of Birmingham
Physiochemical study of electrokinetically treated clay using carbon and steel electrodes

The physical and chemical effects of applying a potential difference across English China Clay (ECC) samples between pairs of both inert (compressed carbon) and metal electrodes were investigated. The findings of a case study using a natural clay were used to design a controlled laboratory programme. Homogeneous ECC specimens were electrokinetically treated for 3, 7, 14 and 28 days and tested for plasticity, undrained shear strength, water content, pH, conductivity, Fe and Al concentrations and zeta potential. The pH and Fe ion concentrations, along with the expected water content variations, dominated the physical property changes in the soil.

Contacts: Professor C. D. F. Rogers, Dr D. Boardman

V. B. Nguyen, University of Birmingham
Numerical modelling of reinforced concrete bridge pier under artificially generated earthquake time-histories

This thesis focuses on the numerical generation of artificially generated earthquake time-histories (AGETH) fitting to a design response spectrum (Eurocode 8: ENV and prEN versions) as well as the numerical modelling of reinforced concrete piers under monotonic, cyclic and earthquake loadings. In particular, attention is mainly focused upon the validation of finite element (FE) smeared crack models and the minimum representative number of AGETH required for non-linear dynamic analysis. A minimum representative number of AGETH from 6 to 11 is suggested for a non-linear dynamic analysis depending on the confidence band required.

Contact: Professor A. H. Chan

A. Royal, University of Birmingham
Hydraulic retardation of contaminant transport through cement-bentonite walls

Diffusion experiments with ammonium chloride and sodium chloride (used separately) across cement-bentonite samples were conducted alongside diffusion experiments exposed to opposing hydraulic gradients (1-5) to investigate the effects of opposing average linear velocities on the diffusive migration. Classification tests were performed on samples of cement-bentonite exposed to ammonium chloride and sodium chloride solutions to determine the effects on the engineered barrier by the permeants. Experimental evidence suggests that an opposing average linear velocity will affect the transport of the contaminants through the cement-bentonite samples via diffusion, although the migration was not terminated as diffusive breakthroughs were found in each test.

Contacts: Professor C. D. F. Rogers, Dr D. Boardman, Dr M. Rivett

M.-H. Yu, University of Birmingham
Geohazards associated with rising groundwater in urban areas affected by former coal mining

Geohazards due to rising groundwater in the Durham Coalfield were investigated by reviewing its geology and mining history. Hazards, including mining subsidence, mine-induced seismicity, gas expulsion and groundwater pollution, were assessed for the worst-case scenario of a complete cessation of mine pumping. Groundwater flow mechanisms were deduced from a conceptual model of regional hydrogeology and numerical modelling using MODFLOW, accounting for hydrogeological changes due to mining activity. Groundwater data show many areas to have reached a steady

state, though coastal areas are still experiencing rising groundwater levels and consequent risks of fault reactivation, evidence for which is starting to emerge.

Contacts: Dr I. Jefferson, Professor M. Culshaw

A. T. Harrison, University of Bristol

A performance framework for the soil strengthening properties of fibre-reinforced sand

The mechanical effects of the addition of short flexible fibres to Hostun sand were studied in one-dimensional compression and in direct shear. The presence of flexible fibres mimics the presence of roots in natural soils. Samples were prepared by combinations of tamping, spooning and vibration. Addition of fibres increased the peak strength of the sand and led to increased ductility. A relationship was obtained linking shear strength with sample density and stress level and fibre content.

T. Sadek, University of Bristol

The multiaxial behaviour and elastic stiffness of Hostun Sand

Stress probe tests in multiaxial apparatus explored the non-monotonic behaviour of dry Hostun sand. Stress response envelopes showed kinematic deviatoric response linked with the current stress state and recent stress history. For these tests, the deviatoric section through the phase transformation surface was somewhat independent of history. Dynamic tests used Bender/Extender elements capable of sending shear and compression waves through the soil specimen. Combining direct and diagonal wave measurements it was possible to deduce the full set of anisotropic parameters. The effects of the inherent and stress induced anisotropy on the small strain stiffness of Hostun sand could be distinguished.

Sponsored by EPSRC, University of Bristol

Contact: Professor D. Muir Wood

Sponsored by University of Bristol, Needham Cooper Trust

Contact: D. Muir Wood

X. Borghi, University of Cambridge

Lubrication and soil conditioning in pipe-jacking and tunnelling

The thesis deals with two applications of soil conditioning to soft ground tunnelling. (1) The effects of soil conditioning on the operation of the Channel Tunnel Rail Link's earth pressure balance tunnelling machines have been back-analysed. This allowed suggesting adequate conditioners (foam or polymer) for different ground conditions, as well as appropriate injection rates. (2) A physical model replicating the pipe-jacking process has been devised to measure the effects of the lubricant on the radial effective stresses on the pipes. Tests performed using different chemical compositions demonstrated that the lubricant composition significantly affects the rate of build-up, as well as the final magnitude of effective stresses on the pipes.

Sponsored by EPSRC, Pipe Jacking Association, Nishimatsu Construction Ltd, British Tunnelling Society

Contact: Professor R. J. Mair

F. Hernandez-Martinez, University of Cambridge

Ground improvement of organic soils using wet deep soil mixing

Research was undertaken into the applicability of the wet deep soil mixing method to the stabilisation of organic soils. Laboratory-scale mechanical and auger mixing techniques were used to stabilise organic clays and peat with a range of cementitious binders. Variables included type, water content and initial density of the soil, type, quantity and water:solids ratio of the binder and soil:binder ratio. The effect of elevated temperatures, carbonation levels and relative humidity on ageing was also investigated as well as the effectiveness of constructing single and overlapping columns. Strength, stiffness and microstructural analyses were used to assess and compare the results.

Sponsored by Cambridge Gates Trust, Mexico's National Council of Science and Technology (CONACyT) and the US Federal Highway Administration National Deep Mixing (NDM) Research Program.

Contact: Dr A. Al-Tabbaa

H. Mitrani, University of Cambridge

Liquefaction remediation techniques for existing buildings

The problem of developing efficient and economical liquefaction remediation methods for existing buildings has not been studied extensively. This thesis describes dynamic centrifuge tests undertaken to try and increase understanding of three such remediation methods: containment walls, cemented zones and inclined, non-loadbearing micro-piles. Centrifuge tests with a simple single degree of freedom frame structure founded on both unimproved and improved soil profiles were carried out for direct comparison. This research offers valuable information about the most important aspects of behaviour of the remediation methods studied. The results obtained can help in the design of liquefaction remediation schemes for existing buildings.

Sponsored by EPSRC, Soletanche-Bachy (NEMISREF project)

Contact: Dr. G. Madabhushi

M. Foundoukos, Imperial College London

Investigation of soil anisotropy using a hollow cylinder apparatus and numerical analysis

A critical evaluation is made of recently developed models that address the marked anisotropy of simple geomaterials. A series of parametric Finite Element simulations is reported, exploring how these models behave under a variety of simulated stress paths. Related experiments are described with a large Hollow Cylinder Apparatus (HCA) that extend the data available concerning the anisotropy of Ham River sand, including its behaviour when sheared undrained after consolidation with the major principal stress axis rotated from the vertical. The study also assesses the potential non-uniformity of stresses and strains within the HCA samples through a set of advanced FE simulations.

Sponsored by Aristotle Onassis Foundation, Imperial College

Contact: Professor R. J. Jardine, Dr L. Zdravkovic

J. Hancock, Imperial College London

The influence of duration and the selection and scaling of accelerograms for engineering design and assessment

This thesis presents a state-of-the-art review of the influence of strong-motion duration on structural damage supplemented by additional studies on masonry structures and on RC frames using spectrally-matched records, generated from real accelerograms using a new wavelet-based technique. A

positive correlation is found between duration and damage measured by absorbed energy or low-cycle fatigue, but not when damage is measured by peak displacement. The thesis explores the number of accelerograms required for stable estimates of inelastic response, showing that the wavelet-based spectrum-matching method reduces the variability of response by a factor of 3 compared with conventional linear scaling of accelerograms.

Sponsored by EPSRC, Marie Curie Fellowships

Contact: Professor J. J. Bommer

S. Kontoe, Imperial College London

Development of time integration schemes and advanced boundary conditions for dynamic geotechnical analysis

This thesis presents several enhancements to the dynamic analysis of geotechnical problems, the most important being the generalized-α algorithm, an unconditionally stable second order accurate time integration scheme with controllable numerical dissipation, and a domain reduction methodology (DRM). Both were implemented in the finite element program ICFEP and further developed to deal with dynamic coupled consolidation problems. The thesis demonstrates the dual role of the DRM, as this method not only reduces the domain that has to be modelled numerically, but in conjunction with the standard viscous boundary or the cone boundary also serves as an advanced absorbing boundary condition. Finally, dynamic and quasi static FE analyses were undertaken to model the seismic response of a highway tunnel that experienced severe damage during the 1999 Duzce earthquake in Turkey.

Sponsored by GCG, London

Contact: Dr L. Zdravkovic and Professor D. M. Potts

A. Moharram, Imperial College London

Earthquake loss estimation and structural vulnerability assessment for Greater Cairo

A multi-tiered earthquake loss assessment methodology is described using Greater Cairo as a case study. Data on tectonic configuration, seismicity, geological structures and soil conditions is utilised to develop a ground shaking model. Satellite imagery is employed, alongside extensive field surveys and information on prevalent design and construction practices, to delineate the region into geographical references of building stock and soil characteristics. Adopting a combination of nonlinear analysis and more simplified methods, seismic vulnerability functions for representative building models are evaluated. The results are used to build-up an event-based loss model which can also be applied to other similar regions.

Contact: Dr A. Y. Elghazouli, Professor J. J. Bommer

R. Monroy, Imperial College London

The influence of load and suction changes on the volumetric behaviour of compacted London clay

This thesis describes a laboratory based experimental investigation into the behaviour of unsaturated compacted London clay, subjected to a variety of complex stress paths that involved changes in matrix suction and applied total stress. Samples statically compacted to the same initial conditions were tested in a suite of novel osmotic oedometers developed at Imperial College, which are also capable of measuring radial total stress. The experimental results were interpreted within the framework of existing unsaturated soil models, showing that most of the observed behaviour is captured by these models. In addition, the fabric study, using scanning electron microscopy (SEM) and mercury intrusion porosimetry (MIP), revealed the importance of fabric changes in an unsaturated clay on its overall mechanical behaviour.

Sponsored by EPSRC

Contact: Dr L. Zdravkovic

S. Nishimura, Imperial College London

Laboratory study on anisotropy of natural London Clay

A substantial study is reported of the shear strength and yielding anisotropy of London Clay from the Heathrow T5 site. Development of a resonant column torsional shear Hollow Cylinder Apparatus (HCA) and its controllers allowed the 4-D stress variables (q, pρ, b and $\forall$) to be varied in an extensive series of consolidated-undrained tests on block samples. Strong anisotropy was revealed in both S_u values and effective stress parameters that results from the fissured-macro and oriented-micro fabrics. Parallel triaxial tests and HCA simple shear tests on rotary samples established the variation of anisotropy of strength and stiffness with depth.

Sponsored by EPSRC, BAA & London Underground

Contact: Professor R. J. Jardine

G. R. Taylor, Imperial College London

Building response to tunnelling-induced ground subsidence: some case histories from the Jubilee Line

Comprehensive field case studies have been compiled for a number of buildings in the London Bridge area where complex tunnelling, station construction and protective measures took place. Building responses are assessed, linking them to construction activities, geology and building stiffness. Attention is given to the initiation and propagation of cracks and movement around pre-existing features and observed damage compared with estimated damage using standard damage categories. Generally damage was negligible to slight and superficial. Settlement of buildings treated by compensation grouting increased abruptly on cessation of the grouting. Long-term movements over a three-year period were consistent with other JLE case studies.

Sponsored by EPSRC

Contact: Professor J. B. Burland, Dr J. R. Standing

U. Langer, Loughborough University

Shear and compression behaviour of undegraded municipal solid waste

In a landfill, waste is the largest structural element and controls both the stability and integrity of the lining system. A classification system was developed to allow assessment of factors controlling waste mechanical behaviour. This included consideration of component material type, size, shape and degradation potential. A waste sorting analysis was conducted to demonstrate its use. A range of synthetic waste classifications was tested in large scale direct shear and compression element tests. Measured behaviour of the synthetic wastes was found to be comparable to values for real waste. Relationships were demonstrated between classification of a waste sample and its mechanical behaviour.

Collaborator: LIRIGM, Joseph-Fourier University, Grenoble

Contact: Dr N. Dixon

J. Walstra, Loughborough University
Historical aerial photographs and digital photogrammetry for landslide assessment

This study demonstrated the value of historical aerial photographs as a source for monitoring long-term landslide evolution, which can be obtained using appropriate photogrammetric methods. The range of outputs that can be derived from historical photographs was explored using two landslide case studies (Mam Tor and East Pentwyn). Outputs included geomorphological maps, automatically derived elevation models and displacement vectors. It was demonstrated that these could be used to monitor landslide evolution. A wide range of imagery was assessed in terms of quality, media and format. A relationship was established between image ground resolution and data accuracy.

Contact: Dr N. Dixon

J. E. Norris, Nottingham Trent University
Root mechanics applied to slope stability (2006)

This study investigated reinforcing embankments and cut slopes with natural vegetation. Biological characteristics and mechanical properties of roots were reviewed and key properties identified for slope stability. Interactions between root systems and soil were investigated. In situ root-soil strength and pull out resistance of roots were measured. Relationships between root morphology and pull out resistance were discovered and a revised classification scheme proposed. Properties of roots required for slope stability analysis calculations were identified and assessed, methods of slope stability analysis reviewed and suitable methods identified that include vegetation effects. Experimental data was used to determine input parameters for root properties. Further modelling determined changes in stability when vegetation is removed from a slope.

J. A. Pickhaver, University of Oxford
Numerical modelling of building response to tunnelling

Numerical methods have been developed to estimate the likely extent of settlement-induced damage caused to masonry buildings by nearby tunnelling operations. New 3D finite element procedures were developed in which the soil/structure interaction effects are modelled using an arrangement of 'equivalent masonry beams' placed on the ground surface to represent the facades of a masonry building. Guidelines were developed to relate the properties of the equivalent masonry beams to the geometry, stiffness and self-weight of the individual facades. The resulting model is compared with a documented case study.

Sponsored by Commonwealth Scholarship Commission

Contact: H. J. Burd, Professor G. T. Houlsby

J. Black, Queen's University, Belfast
The settlement performance of a footing supported on soft clay reinforced with vibrated stone column

The stone column technique has been used extensively as a method for reinforcing soft ground over the past 30 years. Performance in relation to bearing capacity is well researched and documented; however, information in relation to settlement performance is scarce. The research reported in the dissertation dwells on this aspect. Tests were performed on samples 300 mm in diameter and 400 mm in height installed with various lengths of granular columns. The findings of the research have 'far reaching implications that may invite a serious debate in relation to the application of vibrated stone columns as a ground improvement technique.

Contact: Dr V Sivakumar

C. M. Chan, University of Sheffield
A laboratory investigation of shear wave velocity in stabilised soft soils

Experiments were conducted on stabilised clays to investigate relationships between shear wave velocity, and hence small strain stiffness, and shear strength or one-dimensional compressibility. Speswhite kaolin and two natural clays, from Malaysia and Sweden, were stabilised with either cement or a 1:1 mix of cement and unslaked lime. For each clay-binder combination, a good correlation was established between shear wave velocity, measured with bender elements, and shear strength over a range of binder contents and curing periods. From tests in an instrumented oedometer, a correlation was also established between shear wave velocity and constrained modulus beyond the vertical yield stress.

Sponsored by Ministry of Science, Technology and Environment, Malaysia

Contact: Dr C. C. Hird

L. Cheng, University of Sheffield
Dual porosity reactive transport modelling

Dual porosity reactive transport modelling has received increasing attention in tackling groundwater problems. A general dual porosity multi-component reactive transport code MIN3PDUAL has been developed and verified against the established codes. This code is capable of simulating sophisticated physical and chemical processes in dual porosity media for 1-D, 2-D and 3-D and was used as a modelling tool in assessing the fate and transport of MTBE in a Chalk aquifer. The field investigation and modelling results showed that dual porosity transport plays an important role in MTBE attenuation in the Chalk aquifer. Both the MTBE concentrations measured in the field and the plume development of MTBE are predominantly controlled by the dual porosity effects rather than degradation.

Contact: Professor D. Lerner

B. Chisala, University of Sheffield
Assessing microbiological risks to urban groundwater from leaking sewers

Urban groundwater in the UK is perceived to be at high risk of pollution and so is under used. However, in recent years it has been recognised as a potentially valuable resource due to problems associated with its under use. To become more sustainable in urban groundwater use we need to have risk tools to make evidence-based judgements on pollution risks. One such tool is the recently developed Borehole Optimisation System (BOS), which predicts the risk of pollution to groundwater in urban areas. Therefore, BOS was initially used to assess MTBE risks from contaminated land, as a way of developing familiarity with the way BOS was coded and as a first step in the methodology development. The BOS framework was then extended and used to assess microbiological risks from leaking sewers to urban groundwater.

Sponsored by Commonwealth Scholarship Commission, Environment Agency

Contact: Professor D. Lerner

M. Jamaludin bin Md Noor, University of Sheffield

Shear strength and volume change behaviour of unsaturated soils

A shear strength model and volume change framework that link volume change and mobilised shear strength have been proposed for partially saturated coarse-grained soils at low stress levels. The shear strength model takes the form of a warped-surface envelope in τ: $(\sigma - u_a)$: $(u_a - u_w)$ space. The volume change framework considers volume change behaviour due to load increase and inundation within a single framework. Data from large diameter triaxial tests on 10mm gravel specimens have verified the applicability of the shear strength model and the hypothetical volume change framework for loading collapse, but further work is required to validate the framework for wetting collapse.

Sponsored by Department of Public Service under the Prime Minister's Office of Malaysia

Contact: Professor A. F. L. Hyde, Professor W. F. Anderson

D. H. Nguyen, University of Sheffield

Statnamic testing of piles in clay

Constant rate of penetration, maintained load and rapid load model pile tests were carried out in a clay calibration chamber. Existing non-linear power laws for rate effects predict the ultimate static pile capacity from rapid load data, but they under predict the stiffness under working loads. A non-linear power law incorporating changing damping parameters was proposed from model pile data and calibrated against tests on a full scale instrumented pile in a stiff glacial till. Softening effects, changes of pore water pressure and the inertial behaviour of the soil around the pile were also reported and discussed.

Sponsored by Ministry of Education and Training, Socialist Republic of Vietnam

Contact: Professor A. F. L. Hyde