Simulation Of A Centrifuge Model Test Of Pile Foundations

It is of great importance to simulate the excavation of foundation pits in centrifuge model tests. A new device was designed with new principles based on the understanding of the stress field in the soil base before and after excavation. A loading system was used to replace the excavated soil so that the appropriate self-weight stress state could be achieved with an increase of centrifugal acceleration before excavation. The compensation unit and the confining structure were simultaneously removed using the loading unit to simulate the excavation with accuracy. The device was made using a series of new structures for a high degree of automation and good accuracy in simulating the excavation of foundation pits. This device can be used to test a wide range of pit foundations and supporting structures. All of the components of the device were carefully designed to minimize their size and mass with a good control on the deformation of themselves. The device was confirmed to be effective in simulating the excavation of foundation pits at the 50-g level by a series of centrifuge model tests. The true paths of the stress and deformation of the foundation pit could be reasonably simulated in the centrifuge model tests, which cannot be captured by the traditional method in which the excavation was conducted previously at the 1-g level. The traditional method underestimates the earth pressures and the deformation of the soil due to the excavation of the foundation pit according to the comparison tests.

This proceedings book gathers contributions presented at the First International Conference on Embankment Dams (1st ICED, Beijing, 5–7 June 2020), which was the inaugural conference of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) Technical Committee TC210 on Embankment Dams. The contributions address five themes: (1) case histories on the failure of embankment dams and landslide dams; (2) dam failure process modelling; (3) soil mechanics for embankment dams; (4) dam risk assessment and management; and (5) monitoring, early warning and emergency response. These proceedings offer a unique resource that systematically presents recent dam breaching cases, their social impact, associated risk management strategies, and disposal methods for failed dams. It is an excellent reference guide for dam and levee engineers, flood safety officials, and emergency management agencies.

This SBIR 2 final report covers three areas: (1) current state of the art of the human factors effects of flying thrust vectored, or supermaneuverable, aircraft, (2) the development and validation of a model of the 3 axis Dynamic Environment Simulator (DES) centrifuge, and (3) potential upgrades to the 30 year old DES to enhance its performance. The F-22 will be the first production thrust vectored aircraft in aviation history. Because of its pitch axis thrust vector control, the F-22 can pitch at high rates of angular velocity as it flies. The human factors effects of controlling such an aircraft are unknown. The DES was modeled in order to evaluate its ability to replicate some multi-axis accelerations, or agile maneuvers. The MATLAB model allows researchers the ability to investigate such supermaneuvers as the Cobra, Herbst, and Hook on a PC before using the DES. It appears DES arm onset improvements above 3.5 G/sec will not improve agile flight simulation; however, the addition of a fourth degree of freedom (yaw axis platform for seat) is likely to enhance multi-axis simulation fidelity.

This open access book presents work collected through the Liquefaction Experiments and Analysis Projects (LEAP) in 2017. It addresses the repeatability, variability, and sensitivity of lateral spreading observed in twenty-four centrifuge model tests on mildly sloping liquefiable sand. The centrifuge tests were conducted at nine different centrifuge facilities around the world. For the first time, a sufficient number of experiments were conducted to enable assessment of variability of centrifuge test results. The experimental data provided a unique basis for assessing the capabilities of twelve different simulation platforms for numerical simulation of soil liquefaction. The results of the experiments and the numerical simulations are presented and discussed in papers submitted by the project participants. The work presented in this book was followed by LEAP-Asia that included assessment of a generalized scaling law and culminated in a workshop in Osaka, Japan in March 2019. LEAP-2020, ongoing at the time of printing, is addressing the validation of soil-structure interaction analyses of retaining walls involving a liquefiable soil. A workshop is planned at RPI, USA in 2020. .

The U.S. Department of Energy (DOE) is interested in developing tools and methods for potential U.S. use in designing and evaluating safeguards systems used in enrichment facilities. This research focuses on analyzing the effectiveness of the safeguards in protecting against the range of safeguards concerns for enrichment plants, including diversion of attractive material and unauthorized modes of use. We developed an Extend simulation model for a generic medium-sized centrifuge enrichment plant. We modeled the material flow in normal operation, plant operational upset modes, and selected diversion scenarios, for selected safeguards systems. Simulation modeling is used to analyze both authorized and unauthorized use of a plant and the flow of safeguards information. Simulation tracks the movement of materials and isotopes, identifies the signatures of unauthorized use, tracks the flow and compilation of safeguards data, and evaluates the effectiveness of the safeguards system in detecting misuse signatures. The simulation model developed could be of use to the International Atomic Energy Agency IAEA, enabling the IAEA to observe and draw conclusions that uranium enrichment facilities are being used only within authorized limits for peaceful uses of nuclear energy. It will evaluate improved approaches to nonproliferation concerns, facilitating deployment of enhanced and cost-effective safeguards systems for an important part of the nuclear power fuel cycle.

Landslides occur both onshore and offshore. However, little attention has been givento offshore landslides (submarine landslides). Submarine landslides have significantimpacts and consequences on offshore and coastal facilities. The uniquecharacteristics of submarine landslides include large mass movements and long traveldistances at very gentle slopes. This thesis is concerned with developing centrifugescaling laws for submarine landslide flows through the study of modelling submarinelandslide flows in a mini-drum centrifuge. A series of tests are conducted at differentgravity fields in order to understand the scaling laws involved in the simulation ofsubmarine landslide flows. The model slope is instrumented with miniature sensorsfor measurements of pore pressures at different locations beneath the landslide flow. A series of digital cameras are used to capture the landslide flow in flight. Numericalstudies are also carried out in order to compare the results obtained with the data fromthe centrifuge tests. The Depth Averaged Material Point Method (DAMPM) is used inthe numerical simulations to deal with large deformation (such as the long runout ofsubmarine landslide flows). Parametric studies are performed to investigate thevalidity of the developed centrifuge scaling laws under the initial and boundaryconditions given in the centrifuge tests. Both the results from the centrifuge tests andnumerical simulations appear to follow the proposed centrifuge scaling laws, whichdiffer from the conventional centrifuge scaling laws. The results provide a betterunderstanding of the centrifuge scaling laws that need to be adopted for centrifugeexperiments involving submarine landslide flows, as well as giving an insight into theflow mechanism involved in submarine landslide flows.

Effective measurement of the composition and properties of petroleum is essential for its exploration, production, and refining; however, new technologies and methodologies are not adequately documented in much of the current literature. Analytical Methods in Petroleum Upstream Applications explores advances in the analytical methods and instrumentation that allow more accurate determination of the components, classes of compounds, properties, and features of petroleum and its fractions. Recognized experts explore a host of topics, including: A petroleum molecular composition continuity model as a context for other analytical measurements A modern modular sampling system for use in the lab or the process area to collect and control samples for subsequent analysis The importance of oil-in-water measurements and monitoring The chemical and physical properties of heavy oils, their fractions, and products from their upgrading Analytical measurements using gas chromatography and nuclear magnetic resonance (NMR) applications Asphaltene and heavy ends analysis Chemometrics and modeling approaches for understanding petroleum composition and properties to improve upstream, midstream, and downstream operations Due to the renaissance of gas and oil production in North America, interest has grown in analytical methods for a wide range of applications. The understanding provided in this text is designed to help chemists, geologists, and chemical and petroleum engineers make more accurate estimates of the crude value to specific refinery configurations, providing insight into optimum development and extraction schemes.

Thirteen centrifuge model tests on geosynthetic reinforced retaining walls were conducted. These tests were designed to determine the effects of backfill type, reinforcement shape (length), and degree of saturation on displacement and mode of failure under surcharge loading. The backfill types are sand, silty clay, recycled asphalt, and sand-clay materials. Material analysis for the sand and clay soils is obtained.

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The increasing shift towards performance-based geotechnical earthquake engineering design requires an improved understanding of soil-structure interaction (SSI) for buildings on liquefiable deposits. While a number of authors have used centrifuge tests and numerical modelling to study this phenomena, a limited number of studies have been undertaken where numerical models have been validated against well-instrumented centrifuge tests. The focus of this research is to validate numerical simulations of ‘free-field’ conditions and numerical simulations of soil-structure interaction response of isolated buildings on liquefiable deposits against measurements from a centrifuge experiment. The 1D simulations for this study have been developed using the PM4Sand constitutive soil model as implemented in FLAC and the PDMY02 constitutive soil model as implemented in OpenSEES. The consideration of two soil models is one of the distinctive features of this study, as one of the objectives of this research is to compare the relative performance of the two constitutive soil models. The 2D numerical simulations to assess the soil-structure interaction response of isolated structures were developed using the PM4Sand constitutive soil model as implemented in FLAC. The 1D validation that was undertaken in this study show relatively good agreement between the simulated and measured accelerations and excess pore pressures using PM4Sand and PDMY02 for up to moderate levels of earthquake shaking. At high levels of earthquake shaking, good results were obtained using PM4Sand but a poor match with measured values was obtained using the PDMY02 model. The centrifuge experiment results appeared to show that the ground motion properties such as duration and the presence of ‘pulse-like’ qualities have an influence on the measured acceleration and excess pore pressure response even if the intensity of shaking is relatively similar. However, this distinction was generally not captured by the two constitutive soil models considered in this study. Additionally, both of the constitutive soil models significantly underestimated volumetric settlements in the ‘free-field’. The 2D validation undertaken in this study showed that, while the numerical simulations were not able to capture volumetric settlements well, the simulations using PM4Sand generally provided good estimates of total settlement of the structure. The numerical simulations also provided relatively comparable acceleration response in the soil beneath the structures and the ii acceleration response at the base and top of the structure. However, more variability between the measured and simulated excess pore pressure response in the liquefiable soils was noted. The research undertaken in this study shows that numerical simulations are generally able to capture important mechanisms due to liquefaction. In this study, a better response was obtained using the PM4Sand constitutive soil model when simulating ‘free-field’ conditions. However, it should be noted that this observation is based on comparisons against one centrifuge experiment and for the soil parameters adopted in this study.

Simulation of Climatic Conditions in Centrifuge Model Tests

Double porosity soil is characterised by a soil continuum containing two distinct porosities. Typically, this consists of macro-grains (lumps) of soil that have an internal porosity defined as the intragranular porosity. The spaces between lumps are identified as intergranular voids that give rise to the intergranular porosity. Human activities such as land reclamation or mining can give rise to large areas of land with subsoil that exhibits double porosity. The need to build in, or on, these areas is increasing, due to demand for land for industrial usage, infrastructure, and residence. However, the engineering properties of such soils are challenging, and often difficult to predict due to their inhomogeneity and a lack of information about the initial or current parameters. Double porosity mining waste landfills in Northern Bohemia in the Czech Republic were studied in this project. There, decades of open-cast mining of brown coal have left vast areas of land affected by the waste overburden that has been removed and dumped in old mining pits. Redevelopment of areas affected by mining sometimes requires construction on old overburden waste spoil heaps, which consist primarily of lumps of overconsolidated clay and are therefore characterised by a double porosity soil structure. The loading response on these clayfills entails large absolute and relative deformations, which means that ground improvement is normally needed before construction begins, to ensure that both stability and service limit state requirements are met. The primary aim of this research was a comparison, through physical modelling, of ground improvement techniques on double porosity clay landfills. A secondary objective was to contribute to the understanding of the material behaviour governing response to loading and other processes on double porosity soil.

Solve Complex Ground and Foundation Problems Presenting more than 25 years of teaching and working experience in a wide variety of centrifuge testing, the author of Centrifuge Modelling for Civil Engineers fills a need for information about this field. This text covers all aspects of centrifuge modelling. Expertly explaining the basic principles, the book makes this technique accessible to practicing engineers and researchers. Appeals to Non-Specialists and Specialists Alike Civil engineers that are new to the industry can refer to this material to solve complex geotechnical problems. The book outlines a generalized design process employed for civil engineering projects. It begins with the basics, and then moves on to increasingly complex methods and applications including shallow foundations, retaining walls, pile foundations, tunnelling beneath existing pile foundations, and assessing the stability of buildings and their foundations following earthquake-induced soil liquefaction. It addresses the use of modern imaging technique, data acquisition, and modelling techniques. It explains the necessary signal processing tools that are used to decipher centrifuge test data, and introduces the reader to the specialist aspects of dynamic centrifuge modelling used to study dynamic problems such as blast, wind, or wave loading with emphasis on earthquake engineering including soil liquefaction problems. Introduces the equipment and instrumentation used in centrifuge testing Presents in detail signal processing techniques such as smoothing and filtering Provides example centrifuge data that can be used for sample analysis and interpretation Centrifuge Modelling for Civil Engineers effectively describes the equipment, instrumentation, and signal processing techniques required to make the best use of the centrifuge modelling and test data. This text benefits graduate students, researchers, and practicing civil engineers involved with geotechnical issues.

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This thesis describes centrifuge model tests and numerical analyses of tunnels in liquefiable soil. The prototype of the centrifuge tests was the Bay Area Rapid Transit (BART) Transbay Tube (TBT) that connects Oakland to San Francisco, CA, USA. During the tunnel construction, much of the gravelly backfill material around this tunnel was placed loosely under water at a relative density less than 50%. Because of the low relative density of the backfill material around the tube and low unit weight of the tube, there were concerns that tube might suffer large deformation due to buoyancy forces if the backfill material liquefied in an earthquake. BART engaged Fugro West Inc., Oakland, CA to assess the need for ground improvement to mitigate seismically-induced deformations of the tunnel, in particular, the deformations due to uplift of the tunnel in the liquefied backfill. Fugro recommended that their numerical analyses and deformation mechanisms should be further verified using centrifuge model tests. Centrifuge model tests were performed (1) to assess the stability of the BART Transbay Tube, (2) to confirm the uplift mechanisms of the BART Transbay Tube and (3) to verify numerical methods. Test results indicated that the anticipated uplift during the design earthquake would be acceptable (less than about 0.25 m). Three uplift mechanisms were observed in the centrifuge model tests: (1) a cyclic ratcheting mechanism of sand moving under the tunnel associated with cyclic lateral deformations of the tunnel, (2) seepage of water under the tunnel, and (3) heave of soft clay around the trench. Flow of the sand as a viscous liquid was not observed. Two approaches were used to record subsurface movements in the centrifuge experiments. The traditional approach used data from accelerometers and displacement transducers to determine the trajectory of the tunnel. A new approach, Electric Field Displacement Sensors (EFDS), involves installation of source and ground electrodes in the specimen through which well defined multi-directional electric fields can be set up in the specimen. The movement of measurement electrode (which can be attached to an object of interest) can then be determined simply by measuring its voltage. Li (2006) was the first to use this approach, but she used an electrode switching system to sequentially excite multidirectional electric fields. A new contribution of this thesis was the idea that independent electric fields data from different sources can be excited simultaneously at different frequencies; elimination of the need for the switching system has saved a lot of complexity in the equipment and also allowed much improved temporal resolution. After comparing the processed data from the EFDS and traditional approaches, the EFDS can capture the dynamic response pretty well but the EFDS has its limitations. The change of soil resistivity and the heterogeneities of the soil resistivity affect the estimated movements greatly but the change of the soil resistivity can not be captured from the voltage data in the current implementation. With continued work on solving its limitation, the EFDS could become a fairly inexpensive tool for tracking movements. A parametric study was performed using a finite difference program, FLAC 2D, In the numerical simulation, the UBC Sand model (Beatty and Byrne 1998) was used to model the behavior of liquefiable soils. A mesh sensitivity study was performed to decide the appropriate number of nodes for the simulations and how to best model sliding at interfaces between the soil and tunnel. In the parametric study, effects of different geometry characteristics and soil properties on the seismic behavior of the tunnel were explored and the results are summarized in a few dimensionless plots. After effects of various factors on the tunnel performance were understood, suggestions for the future tunnel design were made: (1) densify the liquefiable soils to reduce the cyclic mobility associated with liquefaction, (2) minimize the volume of the liquefiable soils and the thickness of the liquefiable soils underneath the tunnel to reduce the volume of pore water expelled and the space through which water and soil may flow under the tunnel, (3) make the elevation of the interface between high and low permeability materials shallow enough so that high pore pressures are not trapped near the base of the tunnel, (4) make the liquefiable soils as permeable as possible to drain high pore pressures away from the base of the tunnel, and (5) make the unit weight of the tunnel as close as to the surrounding soil.

This special issue collects selected contributions (excluding general lectures) of a Symposium on "Micro to MACRO Mathematical Modelling in Soil Mechanics", which took place at the University of Reggio Calabria, Italy, from May 29th to June 1st, 2018. The Symposium provided an opportunity to enhance the scientific debate on the construction of mathematical models for the description of the physical behaviour of soils, as well as on the suggestions provided by the micro-mechanical observation of the matter. The focus was on the comparison between the appropriateness of models and the need of mathematics to obtain rigorous results, which involves know-how from applied mathematical physics, geotechnical engineering and mechanics of solids. The contributions were selected by the Editors and the other Members of the Scientific Committee of the Symposium: Gianfranco Capriz (Pisa, Roma), Claudio di Prisco (Milan), Wolfgang Ehlers (Stuttgart), James T. Jenkins (Cornell), Stefan Luding (Twente), David Muir Wood (Dundee), Kenichi Soga (Berkeley).

This note presents a computer-controlled mechanical system developed to simulate ground loss in centrifuge model tests. The main application of the system to date had been in the field of mining subsidence prediction. This involves the replication of total extraction of thin mineral seams at depth. A brief overview of total extraction methods is presented, and the performance of the system to replicate these methods in centrifuge model tests is briefly illustrated. The versatility of the system to other applications involving ground loss or boundary displacement problems is also illustrated.

The last decades have shown a remarkable increase in the number of heavy rains, typhoons and earthquakes. These natural phenomena are the main causes for geohazards. As a result the mitigation of geohazards has become a major research topic in geotechnical engineering, and in recent years simulation-based predictions and monitoring tools have been

A new technique is presented for the simulation in a centrifuge of the excavation and lining of a model tunnel. It involves the use of a polystyrene foam core that is placed tightly inside the tunnel lining and that can be dissolved using an organic solvent. This technique is an improvement over other contemporary methods of modeling tunnel construction, such as reduction of air pressure supporting the tunnel lining or gradually draining zinc chloride solution (or some other heavy liquid) from within the lining. The stiffness of the filled tunnel can, approximately, be made to simulate the parent soil. The stiffness of the lining is correctly left in place when the foam core has been dissolved. Since there is no air or fluid pressure involved, there is also no need to seal the ends of the tunnel segment. Results from the first few trials of this technique in a 2 m diameter drum centrifuge are presented. These results demonstrate the usefulness of the technique in modeling progressive collapse of a tunnel and show ample promise of its use in the modeling of the construction of a tunnel using the NATM (New Austrian Tunneling Method).

This book results from the 7th ICPMG meeting in Zurich 2010 and covers a broad range of aspects of physical modelling in geotechnics, linking across to other modelling techniques to consider the entire spectrum required in providing innovative geotechnical engineering solutions. Topics presented at the conference: Soil – Structure – Interaction; Natural Hazards; Earthquake Engineering: Soft Soil Engineering; New Geotechnical Physical; Modelling Facilities; Advanced Experimental Techniques; Comparisons between Physical and Numerical Modelling Specific Topics: Offshore Engineering; Ground Improvement and Foundations; Tunnelling, Excavations and Retaining Structures; Dams and slopes; Process Modelling; Goenvironmental Modelling; Education

This book provides a thorough review of this powerful and sophisticated technique for modelling soil structure interactions. It has been written by an international team of authors.

A new device was developed to simulate the in-flight installation of jacked displacement piles in slopes using centrifuge model tests. In the modularization-based design of this device, the pile installation process is divided into combinations of five-axis movements, which are realized by corresponding electric motors. New structures consisting of combined cubes and cylinders are proposed for the pile top and the picking-up unit. In addition, this device utilizes a series of techniques, such as the use of linear guideways, to increase digital control and the local stiffness of key structures. These measures provide a high degree of automation with good accuracy in determining the locations and vertical extents of piles during installation. The structures and electric motors in the device were optimized to provide high capacities for the load (10 kN) and displacement (260 mm). This device was designed with hollow components to control the size and mass of the entity (only 50 kg) and to satisfy rigorous requirements regarding the allowable deformation and stability levels during centrifuge model tests. The effectiveness of the device was verified using pile installation tests under various conditions. The test results were compared with results that were obtained using pre-flight pile installation. Overall, the pile installation method influenced the responses of the pile-reinforced slopes. For example, the loading-induced displacement of the slope with piles installed in-flight was considerably greater than that in the slope with piles installed at the 1g level when the load was near the limit.

Centrifuge modeling has become a popular and powerful experimental tool in geotechnical engineering. The centrifugal acceleration, which is used to simulate the gravitational acceleration, varies within a model in both magnitude and direction. As a result, the stress field in a centrifuge model is different from that in the prototype being simulated. This paper presents the results of a numerical simulation of the effect of the variation in radial centrifugal acceleration on the stress distribution in a centrifuge model, and its impact on the accuracy of test results. The influence of the centrifuge radius and the size of a model container is investigated.

This book contains technical papers, presented in a discussion session at the XI International Conference on Soil Mechanics and Foundation Engineering held in San Francisco in 1985, on the role of centrifuge in geotechnical testing, with descriptions of test facilities.

The extremes of constitutive and centrifuge modelling are explored here, with a range of lectures addressing specific areas of these two types of modelling as well as on specific design problems and the themes of failure, deformations and interfaces.

This research effort explored the feasibility of using a centrifuge as an experimental simulator to measure free-field blast parameters very near the explosive charge. A series of experimental blast events was conducted in the 30 g to 80 g range using the centrifuge test facility located at Kirtland AFB New Mexico. The results of these tests concluded that the use of a centrifuge simulator is a workable concept for the determination of blast parameters. The simulation of high-explosive effects through gravity scaling permits the use of small charges in the centrifuge simulator and it can easily be refurbished after each test. More importantly, the use of the centrifuge simulator preserves the gravity scaling relationships which are usually distorted during replica model testing. (Author).

The Joslyn steam release incident in 2006 has significantly influenced the approval process for steam assisted gravity drainage (SAGD) projects, which now require rigorous caprock integrity assessment to be conducted. In the past, most of the research efforts have been devoted to reservoir geomechanical simulation studies of caprock integrity. Physical modeling is conducted to a lesser extent, as it is difficult to carry out physical modeling of prototypes at such a scale as SAGD projects. Within the Geotechnical Centrifuge Experimental Research Facility (GeoCERF) at University of Alberta, research is ongoing to utilize the newly built 50g-ton beam centrifuge for physical modeling study of caprock failure mechanisms at high gravitational fields. The centrifuge model will be spun at 100g. According to the scaling law, a 20m thick caprock formation can be simulated using only 20cm thick test material, which makes scaled physical modeling of caprock failure possible. Prototype, reservoir geomechanical simulation and centrifuge modeling are closely integrated in this research. Caprock is deemed as homogeneous material without any pre-existing faults or weak planes. Thus, shear failure and tensile failure are the two major failure modes of caprock to be explored. In reservoir geomechanical simulations, caprock behaviour is described using the elasto-perfectly plastic model with Mohr-Coulomb failure criterion. The development of shearing zones in caprock is analyzed along with displacement profile evolutions at the base of caprock. According to parametric analysis, caprock shearing failure is commonly observed for caprock with different mechanical properties and the shearing patterns of caprock at failure are the same with the vertical displacement at the base of caprock being the main driving force regardless of material property differences. In addition, the vertical displacement profiles at caprock shearing failure also share the same characteristics. A custom-designed electromechanical device named Geomechanical Caprock Deflection Mechanism (GeoCDM) was successfully built and commissioned within GeoCERF to fail the caprock at 100g. In this research, over-consolidated Speswhite kaolin with consistent properties is employed to mimic the caprock in the centrifuge models for the purpose of eliminating the influences of property variability of in-situ materials. Consolidated-drained triaxial tests are conducted on samples cored from the kaolin block and the test results reveal that there are significant property differences between the caprock shale and the over-consolidated Speswhite kaolin in terms of material stiffness, strength and dilation behaviour after shearing. This research is focused on the feasibility study of centrifuge modeling of caprock integrity; however, for future studies, creating synthetic materials with close properties to caprock shale should be a research focus. Through an image-based displacement measurement technique of particle image velocimetry (PIV), the deformation of the kaolin block can be directly captured. Two Kulite miniature pore pressure transducers are installed inside the overconsolidated Speswhite kaolin block for observation of the internal pore pressure changes and an external pore pressure transducer is connected to the base of the kaolin block. Mariotte Bottle is employed to maintain the hydrostatic pressure inside the centrifuge model. Two preliminary tests were conducted to test the GeoCDM setup. Pore pressure transducers are proven to be working well within the GeoCDM setup and the PIV system can effectively track the soil deformation during centrifuge spinning. However, the PIV analysis results had been compromised due to the faulty hydro-mechanical sealing at the base of the kaolin block, which are now being modified for future tests. For future studies, the results of the centrifuge testing should be compared to those of numerical simulations to verify and modify the numerical tools for SAGD caprock integrity study.

A review is presented of the need for simulation of effects associated with tide, rainfall, temperature variations, etc., in geotechnical centrifuge models. Interest in the overall theme was generated by a perceived need to model rainfall in long-term testing of models of an embankment which was otherwise found to dry out. The system used to overcome this particular problem is outlined, and results are presented. Experience of the authors and others in the wider field is summarized.

Centrifuge model testing plays an important role in investigations of the bearing behavior of pile groups and its underlying mechanisms, for which pile installation simulation is a key issue. Centrifuge model tests were conducted to analyze the effect of different pile installation simulation methods, namely traditional installation at 1 g and in-flight installation at 50 g. Compared to the traditional method, the in-flight pile installation induces two effects: the deformation effect, in which the neighboring soil is made denser, and the shielding effect, in which the existing piles influence the deformation and pore pressure of the neighboring soil. Thus, the limit-bearing capacity and corresponding settlement of the pile group using the in-flight pile installation method are significantly greater, and the deformation and excess pore pressure of the soil near piles are smaller. The traditional pile installation method obtains unrealistic responses of pile groups because it cannot adequately simulate these effects.

In the past decades advances have been made in the research and practice on unsaturated soil mechanics. In 2000 the first Asia-Pacific Conferences on Unsaturated Soils was organized in Singapore. Since then, four conferences have been held under the continued support of the Technical Committee on Unsaturated Soils (TC106) of the International Socie