

YEARLY REPORT 2008

Laboratory of Soil Mechanics (LMS)

0. Introduction

At the request of Dean Parlange dated Feb. 6th, 2009, we have addressed below the five questions concerning the activities of the Laboratory of Soil Mechanics (LMS) in 2008.

1. Teaching (2007-2008)

1.1 Courses offered and student numbers;

Course Title	Instructor	Section ; number of hours	Level, semester	Number of students
Geomechanics	L. Laloui	Génie civil, 42h	Ms, 1&3	12
Écoulements souterrains	L. Laloui	Génie civil, 28h	Bs, 4	52
Mécanique des sols	L. Laloui	ELSTE (Uni. Lausanne & Genève), 21h	Ms, 2	15
Environmental geomechanics	L. Laloui	Doctoral school, 28h	Ph.D	10
Soil Mechanics 2	L. Laloui	MAS Tunnelling, 9h	MAS	10
Mécanique des sols	L. Vulliet	Génie civil, 42h	Bs, 3	58
Soil Mechanics	L. Vulliet	MAS Tunnelling, 9h	MAS	10
Géotechnique et Fondations	M. Gencer & G. Gruaz	Sciences et Ingénierie de l'Environnement, 42h	Bs 5	10
Géotechnique et mécanique des sols	G. Steinmann	HES Fribourg	Bs 3	15
Protection des sols	G. Steinmann	HES Fribourg	Bs 5	15

1.2 Outside teaching and workshops

1. L. Laloui L. & Nuth M.: "Stabilité des digues et des barrages en terre". 3 hours Annual meeting of the Fachleute Naturgefahren Schweiz, Lugano, September 17, 2008, 80 participants
2. L. Laloui: "Advanced Geomechanics for Landslides". 8 hours teaching at the European workshop on Hazard analysis (slide, rockfall, debris flow, snow avalanche), Lausanne, November 26-30, 2007, 60 students
3. L. Laloui: "Geomechanical modeling of a natural slope affected by multiple slip surface failure mechanisms". 3 hours teaching at the European Intensive course on Quantitative Risk Assessment and Risk management, Barcelona (Spain), September 2008, 70 students

4. H. Péron, "Mécanique des sols avancée - Sols non saturés: Phénomène de dessiccation des sols". 3 hours teaching at ENSG Nancy (Ecole Nationale Supérieure de Géologie, 3ème Année - option Géotechnique), June 2008, 28 students

1.3 PhD students

(Completed PhD thesis)

1. Koliji A., PhD student (L. Vulliet advisor), Title: Mechanical behaviour of unsaturated aggregated soils (successful exam in January 2008)
Nominated for the EPFL award of best thesis 2008
2. Péron H., PhD student (L. Laloui advisor), Title: Desiccation cracking of soils (successful exam in January 2008)
Nominated for the EPFL award of best thesis 2008
3. François B., PhD student (L. Laloui advisor), Title: Constitutive modelling of unsaturated soils and hydro-mechanical couplings (successful exam in September 2008)
4. Nuth M., PhD student (L. Laloui advisor), Title: Advanced modelling of unsaturated soils, constitutive and hydro-mechanically coupled finite element analysis (Public defence will be in April 2nd, 2009)
Nominated for the EPFL award of best thesis 2009
Selected by the EPFL Research Commission for the Chorafas award 2009

(names and stage of progress indicating expected date of completion)

5. Obrzud R., PhD student (L. Vulliet advisor), Title: Algorithm for soil parameter determination based on in-situ testing (in progress, to be completed in summer 2009)
6. Shokri N., PhD student (L. Laloui, co-advisor), Title: dominant mechanisms controlling evaporation process (in progress, to be completed in summer 2009)
7. Rascol E., PhD student (L. Vulliet advisor), Title: Soil Dynamics (in progress, to be completed in winter 2009)
8. Chalindar S., PhD student (L. Laloui advisor), Title: Advanced modelling of the behaviour of clays: Time-dependency, chemical reactions and bacterial activities (in progress, to be completed in 2010)
9. Rizzi M., PhD student (L. Laloui advisor), Title: Characterization and constitutive modelling of the behaviour of granular bentonite during thermo-hydro-mechanical processes (in progress, to be completed in 2010)
10. A. Battiato, PhD student (L. Laloui advisor), Title: Characterization and modelling of effects of wheeling on topsoil (in progress, to be completed in 2012)
11. J. Eichenberger, PhD student (L. Laloui advisor), Title: Behaviour of large landslides (in progress, to be completed in 2012)

1.4 Ms students

1. Dura A., Ms student (L. Laloui advisor), Title: Post-thermal aging of soils (successful exam in January 2009)

2. Adel Y., Ms student (L. Laloui advisor), Title: Etude du comportement mécanique des matériaux granulaires compactés non saturés sous chargements cycliques soils (successful exam in June 2008)
3. Passarotto M., Ms student (L. Laloui co-advisor), Title: Coupled hydro-thermo-mechanical analysis of deep radioactive waste disposals (successful exam in June 2008)
4. Akry A., Ms student (L. Laloui co-advisor), Title: Recharge de nappes en afrique du nord - barrages collinaires de rétention de crue, barrages infero-flux – souterrains à travers le lit d'un oued (successful exam in June 2008)
5. Eichenberger J., Ms student (L. Laloui co-advisor), Title: dimensionnement de galeries en charge en milieu anisotrope (successful exam in June 2008)

2. Publications and Presentations (2008)

(full title and link to InfoScience)

2.1 Journal Articles accepted and published in 2008

1. Laloui L., Cekerevac C. "Non-isothermal Plasticity Model for Cyclic Behaviour of Soils". International Journal of Numerical and Analytical Methods in Geomechanics doi :10.1002/NAG 629, Volume 32, Issue 5, Pages 437-460, 2008.
<http://infoscience.epfl.ch/record/102337>
2. Laloui L., Cekerevac C. "Numerical simulation of the non-isothermal mechanical behaviour of soils". Computer and Geotechnics, vol. 35, pp. 729-745, 2008.
<http://infoscience.epfl.ch/record/114509>
3. Laloui L., Leroueil S., Chalindar S. "Modelling of the combined effect of strain rate and temperature on one-dimensional compression of soils". Canadian Geotechnical Journal, 45(12): 1765–1777, doi:10.1139/T08-093, 2008.
<http://infoscience.epfl.ch/record/128612>
4. Nuth M., L. Laloui "Effective Stress Concept in Unsaturated Soils: Clarification and Validation of a Unified Framework". International Journal of Numerical and Analytical Methods in Geomechanics Vol. 32, pp. 771-801, 2008.
<http://infoscience.epfl.ch/record/104546>
5. François B., L. Laloui. "ACMEG-TS: A constitutive model for unsaturated soils under non-isothermal conditions". International Journal of Numerical and Analytical Methods in Geomechanics, vol. 32, pp. 1955–1988, DOI: 10.1002/nag.712 , 2008.
<http://infoscience.epfl.ch/record/118203>
6. Nuth M., Laloui L., "Advances in modelling hysteretic water retention curve in deformable soils". Computer and Geotechnics, Vol. 35 N° 6; pp. 835-844, doi:10.1016/j.compgeo.2008.08.001, 2008.
<http://infoscience.epfl.ch/record/125935>
7. Hoyos L.R., L. Laloui, Vassallo R. "Mechanical testing in unsaturated soils". Geotechnical and Geological Engineering, pp. 675-689, vol. 26/6, doi: 10.1007/s10706-008-9200-9, 2008.
<http://infoscience.epfl.ch/record/121370>
8. Péron H., Delenne J.Y., Laloui L., El Youssoufi M.S. "Discrete element modelling of drying shrinkage and cracking". Computer and Geotechnics, pp. 61-69, vol. 26 doi:10.1016/j.compgeo.2008.04.002, 2008.
<http://infoscience.epfl.ch/record/118741>

9. Mattsson N., G. Steinmann, L. Laloui. "Advanced Compact Device for the In-situ Determination of Geothermal Characteristics of Soils". Energy and Buildings, vol. 40, 1344-1352, 2008.
<http://infoscience.epfl.ch/record/115072>
10. Koliji, A., P. Lehmann, L. Vulliet, L. Laloui, A. Carminati, P. Vontobel, and R. Hassanein. "Assessment of structural evolution of aggregated soil using neutron tomography". Water Resources Research, 44, W00C07, doi:10.1029/2007WR006297, 2008.
<http://infoscience.epfl.ch/record/128609>
11. Salager S., Francois B., El Youssoufi M. S., Laloui L., Saix C. "Experimental Investigations of Temperature and Suction Effects on the Mechanical Behaviour of a Sandy Silt". Soils and Foundations, Vol. 48, N°4, 453-466, 2008.
<http://infoscience.epfl.ch/record/118641>
12. Sanavia L., B. François, R. Bortolotto, L. Luison, L. Laloui. "Finite element modelling of thermo-elasto-plastic water saturated porous materials". Journal of Theoretical and Applied Mechanics, vol. 38, pp. 7-24, 2008.
<http://infoscience.epfl.ch/record/124852>
13. Laloui L., M. Nuth, On the use of the generalised effective stress in the constitutive modelling of unsaturated soils. Computer and Geotechnics, 36 (1-2): 20-23; 10.1016/j.compgeo.2008.03.002, 2009.
<http://infoscience.epfl.ch/record/118500>
14. L. Laloui., B. François. "ACMEG-T: A Soil Thermo-Plasticity Model". Journal of Engineering Mechanics, doi: 10.1061/(ASCE)EM.1943-7889.0000011, 2009.
<http://infoscience.epfl.ch/record/134820>
15. Hueckel T., B. François, L. Laloui. "Explaining thermal failure in saturated clays". Géotechnique (in press), 2009.
<http://infoscience.epfl.ch/record/129017>
16. François B., L. Laloui., C. Laurent. "Thermo- hydro-mechanical simulation of ATLAS in-situ large scale test in Boom Clay" Computer and Geotechnics, vol. 36: pp. 626-640, doi: 10.1016/j.compgeo.2008.09.004, 2008.
<http://infoscience.epfl.ch/record/126460>
17. Koliji A., L. Laloui, L. Vulliet "Behavior of Unsaturated Aggregated Soil in Oedometric Condition". Soils and Foundations, Vol. 49, N°3, 2009.
<http://infoscience.epfl.ch/record/133587>
18. Obrzud, RF ; Vulliet, L ; Truty, "A Optimization framework for calibration of constitutive models enhanced by neural networks". International Journal for Numerical and Analytical Methods in Geomechanics, vol. 33, N° 1, p. 71-94, 2009.
<http://infoscience.epfl.ch/record/121378>
19. Obrzud, RF ; Vulliet, L ; Truty, "A combined neural network/gradient-based approach for the identification of constitutive model parameters using self-boring pressuremeter tests". International Journal for Numerical and Analytical Methods in Geomechanics, volume doi: 10.1002/nag.750.
<http://infoscience.epfl.ch/record/128547>

2.2 Book Chapters (2008)

1. Laloui L., Charlier R., Chazallon C., Erlingsson S., Horny P., Pavšič P., Sršen M. "Water Influence on Mechanical Behaviour of Pavements: Constitutive Modelling". Chapter of the book "Water in Road Structures Movement, Drainage and Effects", pp. 192-214; Eds. A. Dawson, doi: 10.1007/978-1-4020-8562-8_9, Springer, 2008.
<http://infoscience.epfl.ch/record/130143>
2. Charlier R., Laloui L., Brenčič M., Erlingsson S., Hansson K., Horny P. "Modelling Coupled Mechanics, Moisture and Heat in Pavement Structures". Chapter of the book "Water in Road Structures Movement, Drainage and Effects", pp. 175-192; Eds. A. Dawson, doi: 10.1007/978-1-4020-8562-8_11, Springer, 2008.
<http://infoscience.epfl.ch/record/130142>
3. Hermansson A., Charlier R., Collin F., Erlingsson S., Laloui L., Sršen M. "Heat transfer in Soils". Chapter of the book "Water in Road Structures Movement, Drainage and Effects", pp. 69-79; Eds. A. Dawson, doi: 10.1007/978-1-4020-8562-8_4, Springer, 2008.
<http://infoscience.epfl.ch/record/130139>

2.3 Proceedings (2008)

1. François B., L. Laloui "Unsaturated soils under non-isothermal conditions: Framework of a new constitutive model" ASCE Geotechnical Special Publication No 179, pp. 1077-1083, 2008.
<http://infoscience.epfl.ch/record/118642>
2. Laloui L., François B. "Numerical Simulation of an In-Situ underground Experiment for Nuclear Waste Storage". Proceedings of the 12th IACMAG conference, pp. 2345-2355, 2008.
<http://infoscience.epfl.ch/record/128538>
3. François B., Bonnard Ch., Laloui L. "Investigation of the Geomechanical Aspects of a Large Landslide by Means of a Finite-element Method : A Case Study". Proceedings of the 12th IACMAG conference, pp. 4577-4585, 2008.
<http://infoscience.epfl.ch/record/128539>
4. Koliji A., Vulliet L., Laloui L. "Advanced Constitutive Model for Unsaturated Structured Soil with Double Porosity". Proceedings of the 12th IACMAG conference, pp. 709-715, 2008.
<http://infoscience.epfl.ch/record/128540>
5. Hu L. B., Hueckel T., Péron H., Laloui L. "Modeling Evaporation, Shrinkage and Cracking of Desiccating Soils". Proceedings of the 12th IACMAG conference, pp. 1083-1090, 2008.
<http://infoscience.epfl.ch/record/128541>
6. Laloui L., Chalindar S. "Enhanced viscoplastic modeling of soft soils". Geotechnics of Soft Soil – Focus on Ground Improvement, Taylor & Francis, pp. 55-64, 2008.
<http://infoscience.epfl.ch/record/126240>
7. Laloui L., François B., Nuth M., Péron H., Koliji, A. "A thermo-hydro-mechanical stress-strain framework for modeling the performance of clay barriers in deep geological repositories for radioactive waste ". Unsaturated Soils: Advances in Geo-Engineering, Toll et al. (eds), pp. 63-80, 2008.
<http://infoscience.epfl.ch/record/125303>
8. François B., Laloui L., "Thermo-plasticity in unsaturated soils, a constitutive approach". Unsaturated Soils: Advances in Geo-Engineering, Toll et al. (eds), pp. 539-545, 2008.
<http://infoscience.epfl.ch/record/125610>

9. Nuth M., Laloui L., "Advanced hydro-mechanical coupling for unified constitutive modelling of unsaturated soils ". *Unsaturated Soils: Advances in Geo-Engineering*, Toll et al. (eds), pp. 559-565, 2008.
<http://infoscience.epfl.ch/record/125627>
10. Koliji A., Vulliet L., Laloui L., "New basis for constitutive modelling of unsaturated aggregated soil with structure degradation". *Unsaturated Soils: Advances in Geo-Engineering*, Toll et al. (eds), pp. 641-646, 2008.
<http://infoscience.epfl.ch/record/125311>
11. Hu L.B., Hueckel T., Péron H., Laloui L., "Desiccation shrinkage of unconstrained soil in the saturated phase". *Unsaturated Soils: Advances in Geo-Engineering*, Toll et al. (eds), pp. 653-658, 2008.
<http://infoscience.epfl.ch/record/125313>
12. Bouazza A., Abuel-Naga H.M., Gates W. P., Laloui L. Temperature Effects on Volume Change and Hydraulic Properties of Geosynthetic Clay Liners. *The First Pan American Geosynthetics Conference & Exhibition*, pp. 102-109, 2008.
<http://infoscience.epfl.ch/record/121437>
20. Bonnard, C. ; Tacher, L. ; Beniston, M., "Prediction of landslide movements caused by climate change : Modelling the behaviour of a mean elevation large slide in the Alps and assessing its uncertainties". *Proc.10th Int. Symp. on Landslides and Engineered Slopes*, p. 217-227, 2008.
<http://infoscience.epfl.ch/record/130529>
21. Péron, H., Laloui, L., Hueckel, T., and Hu, L. 2008. Desiccation cracking of soils: modeling of stress generation and crack propagation. In *Third International Workshop on Unsaturated Soils, Between Theory and Practice in Unsaturated Soil Mechanics*, 4-6 February 2008, Trento, Italy.
<http://infoscience.epfl.ch/record/134821>
22. Péron, H., Laloui, L., Hueckel, T., and Hu, L. 2008. Numerical modelling of desiccation cracking of soils. In *International Symposium SEC2008 Drought and Constructions*, 1-3 September 2008, Paris.
<http://infoscience.epfl.ch/record/134822>

2.4 Other (2008)

1. Nuth M., Péron H., Laloui L. "Intelligent realisation of ground energy". *GeoDrilling international*, pp. 28-29, vol. 141, April 2008.
<http://infoscience.epfl.ch/record/124795>

2.5 Keynote and Invited Presentations (2008)

1. L. Laloui - "Enhanced viscoplastic modeling of soft soils". Keynote lecture at the 2nd International Workshop on Geotechnics of Soft Soils - Focus On Ground Improvement, University of Strathclyde, Glasgow (UK), September 2008.
2. L. Laloui - "Geomechanical modeling of a natural slope affected by multiple slip surface failure mechanisms". Invited lecture at the Intensive course on Quantitative Risk Assessment and Risk management, Barcelona (Spain), September 2008.
3. L. Laloui - "Environmental Geomechanics, Concepts and Applications". Keynote lecture at the 33rd IGC International Geological World Congress, Oslo (Norway), August 2008.

4. L. Laloui - "A THM framework for modeling clay barriers performance in underground nuclear waste storage". Keynote lecture at the European Conference on Unsaturated Soils, Durham (UK), July 2008.

3. Research Projects (2008)

1. Laloui, L. Swisselectric research (2 years project – 116Kfrs) -Title: Energetic geostructures: a sustainable technology for heating and cooling of buildings.
2. Laloui, L., Swiss Federal Office of Roads (1 year project – 87 Kfrs) - Title: Thermo-Prefabricated Vertical Drain for in-situ consolidation of soils.
3. Laloui, L. Swiss Federal Office of Energy (1 year project – 60 Kfrs) - Title: Innovative improvements of thermal response tests, Phase 2.
4. Laloui, L. National Cooperative for the Disposal of Radioactive Waste, NAGRA (4 years project – 189 Kfrs) - Title: Characterisation and constitutive modeling of the behaviour of granular bentonite during THM processes.
5. Laloui, L. Euratom Research And Training Programme On Nuclear Energy, European Union (3 years project – 230 Kfrs) - Title: Thermal Impact on the Damaged Zone Around a Radioactive Waste Disposal in Clay Host Rocks.
6. Laloui, L. Marie Curie Actions - Research Training Network, European Union (1 year project, 121 Kfrs) - Title: Mountain risks.
7. Laloui, L., Bonnard, Ch., Swiss Competence Center Environment and Sustainability (3 years project – 97 Kfrs) - Title: Triggering of Rapid Mass Movements in Steep Terrain.
8. Laloui, L., Swiss Academy of Engineering Sciences (2 years project – 10 Kfrs) - Title : Thermo-hydro-mechanical behaviour of unsaturated soils.
9. Laloui, L., National Cooperative for the Disposal of Radioactive Waste (NAGRA) (80 Kfrs) Title: Analysis of Mont Terri wet spots origins – laboratory experimental investigations And Anisotropic features of Opalinus clay behaviour.
10. Laloui, L., National Science Foundation – R'Equip programme (460 Kfrs) - Title: Experimental investigations of soils in the context of underground nuclear waste disposal.
11. Laloui, L., Mont Terri Consortium (45 Kfrs) - Title: Experimental and numerical study on damage initiation in the context of the analysis of excavation damage zone along tunnels And Analysis of Opalinus clay self sealing.
12. Diserens E., L. Laloui, A. Alaoui, H.P. Lorenz, A. Szymanski, Swiss Federal Office of Environment (138 Kfrs, 3 years) - Title: Zugleistung, Schlupf und Oberbodengefährdung bei Antriebsreifen.
13. Vulliet, L., Nguyen, V., Laloui, L., Swiss National Science Foundation FNS (3 years project – 172 Kfrs) - Title: Dynamic Properties of Granular Soils and Behavior of Earth Structures under Strong Earthquake Motion.

4. Awards

14. Excellent Contributions Award of the International Association for Computer Methods and Advances in Geomechanics, IACMAG, 2008.

This is awarded to individuals who have made significant contributions in research, academic activities and professional service in the interdisciplinary area of Geomechanics.

5. Administrative efforts at ENAC or EPFL (2008)

1. L. Laloui: Director of the doctoral programme in Mechanics.
2. L. Laloui: Member of the research committee for the School of Architecture, Civil and Environmental Engineering of the EPFL (ENAC).
3. L. Vulliet: Member, Foundation Council, Foundation "Les Bois Chamblard", financing research in Environmental Sciences at EPFL (focussing on bio-diversity). (2003-present)
4. L. Vulliet: Member, Foundation Council of the Presses Polytechniques et Universitaires Romandes (PPUR), Lausanne (1995-Present)

6. Objective 2009

Vision

The Soil Mechanics Laboratory (LMS) focuses its activities of education, research and technology transfer in the field of Geomechanics. Its vision aims at contributing to a sustainable development of our built and natural environment by addressing selected key questions with the highest possible academic standard, within transdisciplinary collaborations and through contacts with industry.

Activities

LMS offers courses from Bs to PhD level in soil mechanics, mechanics of porous media, foundation engineering and groundwater seepage.

Research activities will mainly concentrate on:

- **mechanics of geomaterials**, including constitutive modelling, mechanics of porous media and mixtures, cemented, fissured and structured soils, unsaturated soils, multiphase flow in deformable porous media, cyclic loading, elasto-visco-plasticity, laboratory testing, image processing for mechanical testing;
- **environmental geomechanics** applied to geological disposal of nuclear and hazardous waste, as well as energetic geostructures; thermo-hydro-mechanical coupling effects, clay barriers, dessication cracking;
- **numerical modelling of geomaterials** using finite differences and finite elements, algorithms for non-linear coupled problems, optimization procedures, back- and inverse analysis, modelling of landslides;
- **management of natural hazards**, including monitoring, analysis of landslides and debris flow, risk management.

LMS will continue to active in technology transfer and outreach by offering laboratory tests, numerical modelling and expertise work.

For 2009, the aim is at developing a unique scientific way of thinking in the rapidly expanding field of multi-physics coupled processes in porous materials. This concerns the study of the behaviour of geomaterials with all the complexity of their multi-physical and often multi-scale nature and of their environment. Our framework might be extended to biological processes in the context of an ERC proposal.

We intend to form a strong scientifically competent group of interest in Environmental Geomechanics with a distinct modern focus. Such a group could be an international leader in the area that is gaining momentum worldwide.

Prof. Lyesse Laloui, director of LMS

Lausanne, February 13rd, 2009