





Ehsan Haghighat, Ph.D., P.E.

+1-617-412-9273 
ehsanh@mit.edu 
[Google Scholar Profile](#) 
[LinkedIn Profile](#) 

EDUCATION

- **Massachusetts Institute of Technology** Cambridge, MA, USA
Postdoctoral Associate in Civil and Environmental Engineering Jan. 2017 – Present
Research Area: Computational Geomechanics; Multiphase Flow in Porous Media;
Induced Seismicity; Stochastic Modeling; Machine Learning.
- **McMaster University** Hamilton, ON, Canada
Doctor of Philosophy in Civil Engineering July 2011 – Dec. 2014
Research Area: Computational Geomechanics; Nonlinear Deformation and Plasticity;
Fracture Propagation and Stability Assessment;
Coupled Chemo-Hydro-Mechanical Modeling.
- **Sharif University of Technology** Tehran, Iran
Master of Applied Science in Civil Engineering Sep. 2007 – Feb. 2010
Research Area: Numerical Modeling; Hydraulic Fracturing; Extended Finite Element Method;
Soil Dynamics; Stability Assessment.
- **Persian Gulf University** Bushehr, Iran
Bachelor of Engineering in Civil Engineering Sep. 2003 – Sept. 2007

ACADEMIC HONORS AND AWARDS

- **2019:** [CEE Postdoctoral Scholar Mentoring, Teaching and Excellence Award](#).
- **2013:** [Yates Scholarship, McMaster University](#).
- **2012, 2013:** International Student Excellence Award, McMaster University.
- **2012:** Prestigious Ontario Graduate Scholarship (OGS), McMaster University.
- **2007:** Ranked 18th (among 17691 participants) in Iran's nation-wide M.A.Sc. entrance exam.
- **2007, 2010:** Distinguished student award (top GPA) at both PGU and SUT.

ACADEMIC INTERESTS

- Stochastic modeling and uncertainty quantification of engineering systems.
- Physics-informed machine learning with emphasis on engineering applications.
- Mechanics of structures under extreme loading and environmental conditions.
- Solution methods and large scale simulation.

ACADEMIC EXPERIENCE

- **Massachusetts Institute of Technology** Jan 2017 - Present
[PI: Professor Ruben Juanes](#)
 - **Stochastic modeling:** In this study, we performed stochastic analysis of gas leakage from deep geological gas storage unit with emphasis on risk associated to the leakage; a collaborative study with [Prof. Shaw's group](#) from Harvard University.
 - **Physics-Informed Deep Learning:** Application of modern machine-learning algorithms in solution and inversion (identification) of mechanical systems; A collaborative study with [Dr. Raissi](#) of Brown University that resulted in the open source [SciANN](#) package.
 - **Induced Seismicity:** Forward modeling of induced seismicity at Rangely Oil Field, CO and Aliso Gas Storage Field, CA, due to CO₂ and natural gas sequestration, respectively, using coupled reservoir and geomechanics simulations; a collaborative study with [Prof. Shaw's group](#) from Harvard University.

- **Implicit Interfaces:** Development of 3D vectorized FEM program using the implicit interface approach (enriched-FEM) for statistical study of fault geometry and induced seismicity; significant potential for fundamental studies in the area of reservoir-geomechanics modeling.
 - **Creep Modeling for Reservoir Geomechanics:** Development of a rigorous Poro-Visco-Plastic model for the assessment of creep in reservoirs; a collaborative work with *eni* (an Italian oil company) and Prof. Zoback's group from Stanford University.
 - **Dynamic Simulation of Earthquake Cycle:** Development of a criterion to switch automatically between quasi-static and full-dynamic simulators applicable to long time analysis of stability of faults using rate-and-state friction model; a collaborative work with *eni* (an Italian oil company).
- **McMaster University** July 2011 – Dec. 2014
 PI: Professor Stan Pietruszczak
- **Anisotropic Fracturing:** Development of XFEM and Enhanced Embedded Discontinuity methods for modeling fracturing in anisotropic media; a collaborative project with Canadian Nuclear Safety Commission for the safety assessment of underground storage units.
 - **Embedded Discontinuity:** Development of a new framework namely *Embedded Discontinuity Approach* for the analysis of fracture in continuous media; this framework provides the accuracy of XFEM with standard FEM complexities and computational demands.
 - **Chemo-Plasticity:** Modeling loss of stability and cracking in geomaterials using the Chemo-Plasticity framework; this framework allows the coupling of chemical reaction and evolution of mechanical properties with application to processes such as Alkali Silica/Aggregate reactions in concrete and material dissolution.
- **Sharif University of Technology** Sep. 2007, Feb 2010
 PI: Professor Amir Reza Khoei
- **Fracture Propagation in Porous Media:** Development and implementation of the Extended Finite Element method for multi-interface and hydraulic fracturing problems; I then used the model for safety assessment of dams under dynamic-earthquake loading.

PROFESSIONAL EXPERIENCE

- **Forming Technologies Incorporated** Oct. 2014 – Dec. 2016
 PI: Dr. Viktor Petchenov
- **Forming Process:** Researcher and developer of a new sheet metal forming FEM simulator using the implicit continuum-based thick-shell/large-deformation formulations and level-set based Augmented Lagrange Multipliers.
 - **Linear Algebra and HPC:** Study and development of high-performance linear system solver by incorporation of modern Krylov subspace methods and sparse algorithms, parallelization, and preconditioning which resulted performance improvements of up to 4000x.
 - **Leadership:** Project leader at the mechanics group (June-2015 to Dec-2016) where we successfully studied and completed the new FEM forming simulator and a set of high-performance linear system solvers.

TEACHING EXPERIENCE

- **Massachusetts Institute of Technology**
- **Computational Methods for Flow in Porous Media:** Fall 2018; TA; holding lab sessions; preparation and lectures on the fault stability analysis using coupled reservoir-geomechanics models.
 - **Computer Programming for Engineering Applications:** Fall 2017; TA; holding lab sessions; preparation and lectures on image processing and machine learning.
- **McMaster University**
- **Geotechnical Engineering I/II:** Winter 2013, Fall 2012, Winter 2013; TA; holding tutorial sessions, marking quizzes, and running TA hours.
 - **Bridge Engineering:** Winter 2014; TA; holding tutorial sessions, marking quizzes, and running TA hours.
 - **Engineering Mechanics:** Fall 2011; TA; running tutorial sessions for over 200 students, marking quizzes, and running TA hours.
- **Sharif University of Technology**
- **Finite Element Methods I:** Fall 2009; TA; holding tutorial and lab sessions and designing and marking homeworks.

JOURNAL PAPERS

- Haghighat, E., Raissi, M., Rosende, A.M., Gomez, H., and Juanes, R., *A deep learning framework for solution and discovery of solid mechanics relations*. Under submission, 2019.
- Haghighat, E. and Juanes, R., *SciANN: A Keras wrapper for scientific computations and physics-informed deep learning using artificial neural networks*. Under submission, 2019.
- Haghighat, E., Rassouli, F.S., Zoback, M.D. and R Juanes, *A poroviscoplastic model of creep for reservoir rocks*. Submitted: under review, 2019.
- Haghighat, E., and Juanes, R., *Comprehensive study of poroviscoplasticity with application to subsidence assessment*. Under preparation, 2019.
- Haghighat, E., and Juanes, R., *An implicit interface approach for modeling fault slip in crustal deformation*. Under preparation, 2019.
- Haghighat, E., and Juanes, R., *An Implicit-Interface Approach for Modeling Coupled Flow-Geomechanics and Induced Seismicity*. AGU Fall Meeting Abstracts, 2018.
- Su, X., Nguyen, S., Haghighat, E., Pietruszczak, S., Labrie, D., Barnichon, J.D. and Abdi, H., *Characterizing the mechanical behaviour of the Tournemire argillite*. Geological Society, London, Special Publications, 443, pp.SP443-20, 2017.
- Haghighat, E. and Pietruszczak, S., *On modeling of fractured media using an enhanced embedded discontinuity approach*. Extreme Mechanics Letters, 6, pp.10-22, 2016.
- Haghighat, E. and Pietruszczak, S., *On the mechanical and hydraulic response of sedimentary rocks in the presence of discontinuities*. Geomechanics for Energy and the Environment, 4, pp.61-72, 2015.
- Pietruszczak, S. and Haghighat, E., *Modeling of deformation and localized failure in anisotropic rocks*. Journal of Solids and Structures, 67, pp.93-101, 2014.
- Haghighat, E. and Pietruszczak, S., *On modeling of discrete propagation of localized damage in cohesive-frictional materials*. International Journal for Numerical and Analytical Methods in Geomechanics, 39(16), pp.1774-1790, 2015.
- Khoei, A.R., Vahab, M., Haghighat, E. and Moallemi, S., *A mesh-independent finite element formulation for modeling crack growth in saturated porous media based on an enriched-FEM technique*. International Journal of Fracture, 188(1), pp.79-108, 2014.
- Pietruszczak, S. and Haghighat, E., *Assessment of the slope stability in cohesive soils due to a rainfall*. International Journal for Numerical and Analytical Methods in Geomechanics, 37(18), pp.3278-3292, 2013.
- Khoei, A.R., Moallemi, S. and Haghighat, E., *Thermo-hydro-mechanical modeling of impermeable discontinuity in saturated porous media with X-FEM technique*. Engineering Fracture Mechanics, 96, pp.701-723, 2012.
- Khoei, A.R. and Haghighat, E., *Extended finite element modeling of deformable porous media with arbitrary interfaces*. Applied Mathematical Modelling, 35(11), pp.5426-5441, 2011.

SELECTED CONFERENCE PRESENTATIONS/PAPERS

- E Haghighat and R Juanes, *A deep-learning framework for inference in geomechanics*. Machine Learning in Solid Earth Geoscience Conference, Santa Fe, New Mexico, US (2019).
- E Haghighat and R Juanes, *Coupled Flow and Reservoir Geomechanics: Computational Modeling of Induced Seismicity*. EMI Conference 2018, Cambridge, MA, US (2018).
- E Haghighat and R Juanes, *Modeling hydraulic fracturing using a vectorized 3D implementation of XFEM*. Interpore 10th Annual Meeting, New Orleans, LA, US (2018).
- E Haghighat and S Pietruszczak, *Fourier law with embedded discontinuity*. US National Congress in Computational Mechanics 13, San Diego, CA, US (2015).
- E Haghighat and S Pietruszczak, *On the description of fracture propagation in brittle materials*. In: Computational Geomechanics Ed. Pietruszczak and Pande, ICCE Publ., 2013, pp.158-170.

REFERENCES

- **Prof. Ruben Juanes**

Department of Civil and Environmental Engineering, Massachusetts Institute of Technology

Address: Room 1-363, 77 Massachusetts Avenue, Cambridge, MA, 02139

Phone: +1 (617) 253-7191

Email: juanes@mit.edu

Web-page: juanesgroup.mit.edu

Relation: **Postdoctoral advisor.**

- **Prof. John H. Shaw**

Department of Earth and Planetary Sciences, Harvard University

Address: 20 Oxford St. Cambridge, MA 02138

Phone: +1 (617) 495-8008

Email: shaw@eps.harvard.edu

Web-page: structure.harvard.edu

Relation: **Postdoctoral collaborator.**

- **Prof. Stan Pietruszczak**

Department of Civil Engineering, McMaster University

Address: JHE-228, 1280 Main St West, Hamilton, ON, Canada, L8S4L7

Phone: +1 (905) 525-9140; Ext 24007

Email: pietrusz@mcmaster.ca

Web-page: mcmaster.ca/civil/stanislaw-pietruszczak

Relation: **PhD supervisor.**

- **Prof. Peijun Guo**

Department of Civil Engineering, McMaster University

Address: JHE-227, 1280 Main St West, Hamilton, ON, Canada, L8S4L7

Phone: +1 (905) 525-9140; Ext 27903

Email: guop@mcmaster.ca

Web-page: mcmaster.ca/people/peijun-guo

Relation: **PhD committee member.**

- **Dr. Viktor S. Petchenov, P.E., Senior Research Scientist**

Research and Development Department, SimSolid/Altair.

Address: Burlington, Ontario, Canada, L7N3M6

Phone:

Email: vpetchenov@altair.com

Web-page: SimSolid - An Altair Company

Relation: **Manager/P.I. at FTL.**

- **Prof. Amir Reza Khoei**

Department of Civil and Environmental Engineering, Sharif University of Technology

Address: P.O. Box 11365-9313, Tehran, Iran

Phone: +98 (21) 6616 4277

Email: arkhoei@sharif.edu

Web-page: <http://sharif.edu/~arkhoei/>

Relation: **Master's supervisor.**