

Marc-Ansy Laguerre, Ph.D.

Earthquake & structural engineering ■ Fragility, risk & resilience
Uncertainty quantification & Machine Learning ■ Engineering education

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Research Interests

My research aims to reduce losses from earthquakes and other natural hazards, with a focus on vulnerable reinforced-concrete building stock. I combine nonlinear finite-element modeling, post-earthquake data, and machine learning to understand how buildings are damaged, to quantify their fragility and risk, and to identify retrofit strategies that are effective and cost-effective. My interests include explainable-AI and machine-learning damage models, Bayesian updating of fragility functions, and uncertainty quantification for nonlinear simulation.

Teaching Interests

I am interested in teaching core and advanced courses in structural and earthquake engineering, including structural analysis, reinforced-concrete design, structural dynamics, earthquake engineering, finite-element methods, probabilistic methods and risk analysis, and machine learning for civil engineering. My teaching combines active learning, hands-on physical models, and computational tools (SAP2000, MATLAB, OpenSees, Python) so that students connect theory to structural behavior, and draws on my experience creating educational videos and simulations.

Current Appointments

Postdoctoral Research Associate, Civil and Environmental Engineering

Jul. 2024 – Present

Rice University

Houston, TX

Supervisors: Prof. Reginald DesRoches and Prof. Kalil Erazo

- Conducts research on the seismic damage and fragility of reinforced-concrete buildings using post-earthquake data and nonlinear finite-element simulation.
- Develops machine-learning damage-classification models, using explainable AI to identify key damage drivers.
- Develops empirical, analytical, and disaggregated fragility functions, with Bayesian updating (MCMC).
- Quantifies uncertainty in nonlinear seismic response through forward propagation and global sensitivity analysis.
- Runs large simulation campaigns on high-performance computing resources as a TACC SPARC Fellow.

Adjunct Lecturer, CEVE 325: Structural Analysis & Modeling

Fall 2025

Rice University

Houston, TX

- Taught a core undergraduate course (20 students) on equilibrium, internal forces, influence lines, deformed shapes, and determinate and indeterminate structures under vertical and lateral loads.
- Designed lectures, assignments, and three exams; integrated SAP2000 and MATLAB tutorials and hands-on physical-model demonstrations with the Mola structural kit.
- **Student evaluations:** 100% of students rated overall teaching effectiveness as outstanding (71%) or good (29%).
- **Student comments:** “Dr. Laguerre did a fantastic job of going the extra mile for our learning ... and implemented hands-on activities to demonstrate concepts better.” “Professor Laguerre did an amazing job of ensuring his students understood the material.”

Education

Ph.D., Civil Engineering

May 2024

Rice University

Houston, TX

Dissertation: *Seismic Retrofitting of Low-Rise Reinforced Concrete (RC) Structures: A Multi-Faceted Evaluation.*

Advisor: Prof. Reginald DesRoches **Committee:** Profs. Jamie Padgett, Leonardo Dueñas-Orsorio, Luis Duno-Gottberg

- Addressed the limited knowledge of the seismic vulnerability of Haitian RC buildings and of retrofit solutions suited to them.
- Defined four building archetypes from Haitian construction practice and evaluated five retrofit strategies (RC jackets, RC shear walls, steel braces, buckling-restrained braces, prestressed cables) with validated LS-DYNA and OpenSees models.

- Combined deterministic nonlinear analysis, empirical and analytical fragility, regional risk assessment, and life-cycle cost-benefit analysis to compare the retrofits.
- Found that RC jacketing combined with steel braces (residential) or shear walls (non-residential) offers the best balance of structural performance and cost-effectiveness.

Selected coursework: Earthquake Engineering (Grade: A); Physics-Guided Machine Learning and Data-Driven FEM (Grade: A-); Risk-Based Decision Making under Uncertainty (Grade: A-); Bridge Engineering and Extreme Events (Grade: A); Infrastructure Resilience (Grade: A); Reinforced Concrete Buildings (Grade: A); Soil Mechanics and Foundations (Grade: A+); Soil Mechanics Laboratory (Grade: A+); Leadership Coaching for Engineers (Grade: A).

Graduate Certificate in Teaching and Learning

Rice University, Center for Teaching Excellence

May 2024

Houston, TX

Courses: Principles of Effective Teaching (Grade: A); Research on Teaching and Learning (Grade: A); Practicum in College Teaching (Grade: A); Teaching Portfolio (Grade: A).

- Studied evidence-based, student-centered teaching, including course design, learning objectives, assessment, and creating an inclusive and supportive classroom environment.
- Completed a teaching practicum, including serving as a teaching assistant for Structural Analysis at Rice in 2022.
- Developed a teaching portfolio with a teaching philosophy, a syllabus and assignments for a graduate course in Earthquake Engineering (including a poster-based term project), and evidence of teaching effectiveness.
- Conducted research on teaching and learning (annotated bibliography, essay, and handout) on how education system has evolved and whether curriculum reform, including the balance between liberal and vocational education, can improve it.

M.S., Civil Engineering

University of Pittsburgh (Fulbright Scholar)

Aug. 2019

Pittsburgh, PA

Advisor: Prof. Lev Khazanovich

Selected coursework: Advanced Mechanics of Materials (Grade: A+); Introduction to Finite Elements (Grade: A+); Dynamics of Structures (Grade: A+); Elasticity, Plasticity, and Fracture Mechanics (Grade: A+); Engineering for Sustainable Development (Grade: A).

- **Independent study** (Fall 2018, Prof. Max Stephens): seismic analysis of a typical two-story Haitian RC residential building with masonry infill, comparing construction practices before and after the 2010 earthquake. Modeled both designs in OpenSees and applied equivalent lateral force, modal response-spectrum, and time-history analyses; the pre-2010 design exceeded drift limits, while the post-2010 design met them.
- **Literature review** (under the guidance of Prof. Kent Harries) on bamboo as a construction material, covering its mechanical properties, bamboo-reinforced concrete, seismic performance, economic and environmental benefits, and barriers to adoption (fire, insects, wind, joints, and the lack of design codes).

Graduate Certificate in Latin American Social and Public Policy

University of Pittsburgh, Center for Latin American Studies

Aug. 2019

Pittsburgh, PA

Selected coursework: World War II, the Cold War, and their Impact on Developing Countries (Grade: A); International Organizations (Grade: A); Human Rights: Politics & Practice (Grade: A).

- Completed the certificate alongside the M.S. in Civil Engineering, supported by a Center for Latin American Studies Fellowship.
- Independent study comparing Haiti and the Dominican Republic, examining why the two countries sharing Hispaniola diverged economically, with a focus on human capital and education.
- Analyzed the history of schooling since independence, the role of the language of instruction (French versus Haitian Creole), and the effect of brain drain on each country's development.

B.S., Civil Engineering

Faculty of Sciences, State University of Haiti

Feb. 2015

Port-au-Prince, Haiti

Final project: *Mapping the Swelling Potential of Clay Soils in the Morne Delmas Formation, Port-au-Prince Metropolitan Area, Haiti* (team project, defended Feb. 2015). [View abstract ↗](#)

Selected coursework: Mechanics of Materials; Structural Analysis; Structural Mechanics; Reinforced Concrete (BAEL and ACI); Steel Structures; Bridge Engineering; Soil Mechanics (with laboratory); Foundations; Fluid Mechanics; Hydraulics; Hydrology; Numerical Analysis; Probability; Engineering Mathematics; Surveying; Construction Management.

Supervisors: Dr. Kelly Guerrier (supervisor) and Eng. Yves-Fritz Joseph (tutor)

- Assessed the shrink–swell susceptibility of clay soils underlying much of the Port-au-Prince metropolitan area, which can cause differential ground movement and damage to buildings and infrastructure.
- Adapted a BRGM methodology combining lithological, mineralogical, and geotechnical criteria; integrated laboratory tests on soil samples with existing LNBTP geotechnical data, Atterberg limits, and particle-size data.
- Produced swelling-susceptibility maps in ArcGIS, classifying about 6.0% of the study area as high, 88.6% as medium, and 5.4% as low susceptibility, with high susceptibility around Maïs-Gâté and Village Lamothe.
- Compared the map with building damage from the 2010 Haiti earthquake, highlighting the need to consider geological, geotechnical, structural, and seismic factors together when interpreting damage patterns.

Part-Time Appointments

Lecturer, Reinforced Concrete Design (Eurocode 2)

Faculty of Sciences, State University of Haiti

Feb. 2026 – Present

Remote

- Teaches the undergraduate reinforced-concrete design course according to Eurocode 2, covering flexural design, shear, serviceability (cracking and deflection), slabs, columns, and reinforcement detailing.
- Designs lectures, worked design examples, homework, examinations, and tutorials, delivered remotely.
- Integrates Python-based tools so students can check hand calculations and see how design parameters affect results.
- Serves on undergraduate final-project defense committees, evaluating student projects and providing technical feedback.

Lecturer, Structural Analysis (*Analyse des Structures*)

Department of Civil Engineering, Université Publique de la Grand'Anse

Haiti

- Teaches the analysis of statically determinate structures: idealization and load paths, support reactions, internal-force diagrams (N , V , M), and beams, trusses, and frames.
- Covers influence lines (including the Müller-Breslau principle) and approximate methods of analysis for vertical and lateral loads (portal and cantilever methods).
- Integrates Python and the anaStruct library so students can verify hand calculations and visualize structural behavior.

Lecturer, Earthquake-Resistant Design (*Conception Parasismique*), master's level

Institut des Sciences, des Technologies et des Études Avancées d'Haiti (ISTEAH) ↗

Upcoming

Haiti

- ISTEAH is a Haitian university-level institute, founded in 2013, that trains scientists and innovators through undergraduate, graduate, and doctoral programs.
- Designed a master's course that connects seismology and seismic hazard (including PSHA and site effects) to structural dynamics, response spectra, and the principles of earthquake-resistant design (ductility and capacity design).
- Covers lateral-force-resisting systems, linear and nonlinear seismic analysis (equivalent static, modal, pushover, and time-history), performance levels, fragility and seismic risk, and the retrofit of existing buildings.
- Uses Python and OpenSeesPy for response spectra, dynamic and nonlinear analysis, and vulnerability studies, with case studies from Haiti.

Lecturer, Introduction to the Finite Element Method, master's level

Institut des Sciences, des Technologies et des Études Avancées d'Haiti (ISTEAH) ↗

Upcoming

Haiti

- Will teach a master's course on the fundamentals of finite-element analysis for structural engineering, from the direct stiffness method for bar, truss, and beam elements to the weak form and variational principles.
- Covers shape functions, isoparametric formulation, numerical integration, assembly and boundary conditions, and 2-D plane stress and plane strain elements, with attention to mesh convergence and good modeling practice.
- Uses Python so students can implement simple finite-element codes and compare numerical results with analytical solutions.

- Supported two specialists in managing the IDB's energy projects.
- Accompanied specialists in the supervision of road construction projects.
- Analyzed the costs of road projects and prepared projections for bidding processes to support budget management and resource allocation.
- Contributed to reports and presentations on project progress and challenges.

Research

Machine-learning damage models and fragility from post-earthquake data

- Paired post-event evaluations of 322 buildings from the 2023 Turkey–Syria earthquakes with nine ground-motion intensity measures derived from Turkey's national strong-motion network: PGA, PGV, CAV, RMS acceleration, Arias, Araya–Saragoni, Housner, and PSA at 0.3, 1.0, and 3.0 s.
- Screened the intensity measures for correlation with damage and with each other (Pearson coefficients) and developed maximum-likelihood fragility curves for each damage state.
- Trained a random-forest damage classifier (70/30 train–test split, tuned decision threshold), evaluated it with confusion matrices, precision, recall, F1-score, and ROC/AUC, and interpreted it with SHAP.
- Identified PGA and Araya–Saragoni intensity as the most effective damage predictors for the dataset studied.

Disaggregated fragility and Bayesian updating

- Derived baseline fragility curves from about 335,000 building assessment tags from the 2010 Haiti earthquake, conditioned on number of stories, soil type, wall system, topography, roof type, and building age rather than averaged over the whole building stock.
- Updated the baseline models with 170 detailed RC building assessments to add fragilities for captive columns and priority index (the ratio of wall and column area to floor area).
- Implemented Metropolis–Hastings MCMC in Python (100,000 iterations, burn-in, tuned random-walk proposal) and checked convergence with the Gelman–Rubin statistic.

Uncertainty quantification and sensitivity analysis of RC-jacketed frames

- Propagates uncertainty in the existing frame, the RC jacket, and the ground motion through nonlinear response-history analyses in OpenSees, using models validated against cyclic tests and cross-validated against LS-DYNA.
- Uses variance-based (Sobol) sensitivity analysis and fragility functions to identify the parameters that most influence seismic response and to quantify the effectiveness of RC jacketing for Haitian buildings.

Seismic retrofit of low-rise RC structures

- Reviewed Haitian construction practice and defined four RC building archetypes (one- to three-story, residential and non-residential) designed to the BAEL code used for engineered buildings in Haiti before 2010.
- Built 3-D continuum models of columns, beam–column joints, and jacketed members in LS-DYNA (8-node solid elements with Winfrith concrete, MAT 084; beam-element reinforcement with piecewise linear plasticity steel, MAT 024).
- Implemented a cyclic bond-slip law (friction and bearing components, cyclic deterioration) as a FORTRAN user subroutine for the LS-DYNA implicit solver, and quantified the sensitivity of member response to bond slip.
- Validated the models against laboratory cyclic tests of column bases, beam–column joints, RC-jacketed columns, a prestressed-cable braced frame, and buckling-restrained braces.
- Calibrated 2-D OpenSees frame models (fiber sections, truss braces, shear-wall elements) from the continuum results and cross-validated the two modeling approaches.
- Designed five retrofit strategies (RC jackets, RC shear walls, steel braces, buckling-restrained braces, prestressed cables) to meet FEMA Life Safety objectives at the 2,475-year hazard, and evaluated them with nonlinear time-history analysis.
- Developed empirical fragility curves for four concrete and masonry building classes from 3,527 buildings surveyed after the 2021 Haiti earthquake, using USGS ShakeMap intensities and five damage states.
- Developed analytical fragility curves from pushover-based damage limit states (multiple linear regression, chi-square goodness-of-fit tests) and probabilistic seismic demand models built from 3,200 nonlinear time-history analyses (16 as-built and retrofitted frames, 200 realizations each, 100 ground motions).
- Performed a life-cycle cost–benefit analysis with Monte Carlo estimates of repair and retrofit costs, and produced

maps in MATLAB of expected benefit and cost–benefit ratio across Haiti.

- Showed that RC jacketing combined with steel braces (residential) or shear walls (non-residential) gives the best balance of structural performance and financial return.

Seismic fragility of multi-span simply supported bridges (*course project, Bridge Engineering and Extreme Events, Rice University, Spring 2021*)

- Developed seismic fragility curves for three classes of multi-span simply supported highway bridges (steel, concrete, and slab), using 1,152 nonlinear time-history simulations per class from a published OpenSees dataset on DesignSafe.
- Used four column-drift damage states (slight, moderate, extensive, and complete) with PGA as the intensity measure, and fitted lognormal fragility functions in MATLAB following the FEMA P-58 bounding-demand approach.
- Compared the bridge classes, finding wider separation between damage states for steel and concrete bridges than for slab bridges.

Publications

- [1] **Laguerre, M.-A.** and Erazo, K. (2026). Fragility curves and machine learning-based damage classification models from strong-motion data measured during the 2023 Turkey–Syria earthquake. *Journal of Earthquake Engineering*. [doi:10.1080/13632469.2026.2621840](https://doi.org/10.1080/13632469.2026.2621840) ↗
- [2] **Laguerre, M.-A.** and Erazo, K. (2026). Disaggregated empirical fragility modeling and Bayesian parameter updating for buildings in Haiti. *Buildings*, 16(6), 1137. [doi:10.3390/buildings16061137](https://doi.org/10.3390/buildings16061137) ↗
- [3] **Laguerre, M.-A.**, Salehi, M., and DesRoches, R. (2025). A numerical study on the seismic retrofit of Haitian reinforced concrete building frames. *Earthquake Spectra*. [doi:10.1177/87552930241311975](https://doi.org/10.1177/87552930241311975) ↗
- [4] **Laguerre, M.-A.**, Salehi, M., and DesRoches, R. (2024). Empirical fragility analysis of Haitian reinforced concrete and masonry buildings. *Buildings*, 14(3), 792. [doi:10.3390/buildings14030792](https://doi.org/10.3390/buildings14030792) ↗
- [5] **Laguerre, M.-A.**, Salehi, M., and DesRoches, R. (2024). Seismic retrofit of low-rise reinforced concrete buildings typical to Haiti. *Proceedings of the 18th World Conference on Earthquake Engineering (18WCEE)*, Milan, Italy.

Presentations

Dec. 2025	Leveraging post-earthquake data and machine learning to advance rapid damage assessment and resilience planning. <i>AGU Fall Meeting</i> , New Orleans, LA (poster).
2025	Leveraging post-earthquake data and finite element models for seismic vulnerability assessment and mitigation. <i>Future Faculty Workshop</i> , University of Notre Dame (poster).
2023–2024	Seismic retrofitting of low-rise RC structures. <i>Rice Research & Industry Showcase</i> (posters, 2023 and 2024).
2024	Seismic retrofitting of low-rise RC structures. <i>Trailblazers in Engineering</i> , Purdue University (poster).
Jul. 2024	The impact of earthquakes on sustainable development: insights from Haiti as a case study. <i>U.S.–Brazil Workshop on AI for Urban Sustainability and Resilience to Natural Disasters in the Americas</i> , Rice University, Houston, TX.
Apr. 2024	Seismic retrofitting of low-rise RC structures: a multi-faceted evaluation. <i>Dissertation seminar</i> , Rice University.
Jun. 2023	Seismic retrofit of low-rise RC frames typical of Haiti. <i>Engineering Mechanics Institute (EMI) Conference</i> , Georgia Tech, Atlanta, GA.
Nov. 2022	Seismic retrofitting of low-rise RC buildings. <i>III International Congress on Computing in Civil Engineering (CICIC 2022)</i> , Universidad Nacional de Moquegua, Peru (invited).
Nov. 2021	A brief history of Haiti's construction and solutions to mitigate its seismic risk. <i>International Congress</i> , Universidad Nacional de Moquegua, Peru (invited).

Awards and Honors

2025	SPARC Fellow (Strategic Program to Accelerate Researchers in Computing), Texas Advanced Computing Center
2025	Nominee, Outstanding Postdoctoral Research Award, Rice University
2024	Trailblazers in Engineering, Purdue University
2017–2019	Fulbright Scholarship (administered by LASPAU)
2017–2019	Center for Latin American Studies Fellowship, University of Pittsburgh

Other Academic Distinctions

A consistent record of academic excellence from secondary school through university.

2009–2014	Consistently ranked at the top of the class, Faculty of Sciences, State University of Haiti: 2nd of 200 students (first year, 2009–10), 4th of 122 (second year, 2010–11), and 1st in civil engineering in the years (1st of 37 in 2011–12; 1st of 28 in 2012–13).
2009	Ranked second on the competitive entrance examination of the Faculty of Sciences, State University of Haiti, among thousands of applicants.
2007	Highest possible scores (300/300) in mathematics and physics on Haiti's national secondary-school examination.
2007	Winner of the mathematics contest at College Frère Odile Joseph high school.
2004	Maximum score in mathematics on Haiti's national examination in middle school.

Selected Media Coverage

Jun. 2025	Strengthening seismic resilience in Haiti after devastating earthquakes ↗. <i>ASCE Civil Engineering Source</i> .
Mar. 2025	Building a safer future: Rice researcher works to strengthen Haiti's earthquake resilience ↗. <i>Rice University News</i> .
Mar. 2023	Meet Rice's Graduate Ambassador Marc-Ansy Laguerre ↗. <i>Rice Graduate & Postdoctoral Studies</i> .

Service

Peer review

Reviewer	<i>Bulletin of Earthquake Engineering</i> (Springer Nature)
Reviewer	<i>Discover Sustainability</i> (Springer Nature)
Reviewer	<i>Buildings</i> (MDPI)

Mentoring

Mentor	Mentors and tutors high school and undergraduate engineering students, in topics including mechanics and applications of artificial intelligence in earthquake engineering.
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University and community

2026 – Present	Alumni Ambassador, Rice University. Supports alumni engagement and connections between Rice and its broader community.
2021 – 2023	Treasurer, Graduate Student Association (GSA), Rice University. Managed the association's finances and helped organize events for graduate students.
2021 – 2024	Graduate Student Ambassador, Rice University. Represented graduate students and advised prospective and incoming students on graduate life at Rice.
2018	Fulbright–Amizade Volunteer, Williamson, West Virginia. Week-long community service and cultural exchange in rural Appalachia with the Sustainable Williamson initiative.

Advisory and review boards

Advisor	Advisor, FONCONHA (Learn more ↗). Advises a women-led organization working toward safer, more resilient construction in Haiti.
Member	Review board member, Haiti Nexus (Learn more ↗), Engineering & Technologies, a research nonprofit founded in September 2024.

Outreach and Engineering Education

Founder and Content Creator, Génie 360 (genie360.org)

Jan. 2018 – Present

Engineering education initiative for Haiti

Online

- Produces civil-engineering videos and interactive web simulations in Haitian Creole and French on structural and earthquake engineering, construction practice, and computational methods such as Monte Carlo and Markov chain simulation.
- Independently develops, records, and edits all educational content to make engineering knowledge more accessible.
- Builds interactive demonstrations that connect theory with visualization and numerical simulation, with applications relevant to the Haitian built environment.
- A Génie 360 video demonstrating how tuned mass dampers affect building vibrations ([watch](#) ↗) was selected by the Centre franco-ontarien de ressources pédagogiques for *QUAD9* (vol. 22, no. 1, February 2027), an educational

webzine developed for the Ontario Ministry of Education for French-language students in grades 7–10.

- Collaborates with organizations in Haiti, with more than 30 participations in their workshops and webinars:
 - [Ti Koze sou Konstwixsyon](#) ↗ (TKSK; Talk about Construction), an organization that promotes safe, earthquake-resistant construction through trainings, workshops, and a weekly interactive program.
 - [FONCONHA](#) ↗ (*Femmes Organisées pour une Nouvelle Construction d'Haïti*), a women-led organization working toward safer, more resilient construction and a greater role for women in Haiti's building sector.
 - [Haiti Nexus](#) ↗, a nonprofit advancing research related to Haiti and tropical countries through publishing, research contests, and webinars.
 - [SARVCR](#) ↗ (Society for Hazards, Risks, Vulnerabilities, Disasters, and Resilience), which organizes Haiti's annual national conference on disaster risk management.

Field Reconnaissance

Post-Earthquake Damage Assessment Volunteer

2021

Structural Extreme Events Reconnaissance (StEER) Network

Haiti

- Supported StEER field teams conducting rapid damage assessments after the August 2021 Haiti earthquake, working with local engineers and volunteers to document building characteristics and observed damage.
- Contributed to a post-earthquake database of more than 6,000 assessed buildings, one of the most comprehensive records of building performance in Haiti and an important resource for understanding the vulnerability of the national building stock.
- Used this database to develop the empirical fragility curves for Haitian concrete and masonry buildings published in my first journal paper (*Buildings*, MDPI, 2024), which also supported the seismic risk maps and the analytical-versus-empirical fragility comparison in my doctoral research.

Building Inventory Assessment

Feb. 2014

World Bank / University of Pittsburgh (Prof. Louise K. Comfort)

Port-au-Prince, Haiti

- Selected among a group of excellent civil engineering students to take part in a building-inventory assessment mission led by Prof. Louise K. Comfort of the University of Pittsburgh.
- Evaluated 81 buildings in Port-au-Prince using the Inventory Data Capture Tool, documenting structural systems, construction characteristics, building condition, and earthquake damage indicators.
- Contributed to characterizing the vulnerability of the city's building stock, an early field experience that shaped my later research on the seismic risk of Haitian buildings.

Skills and Languages

Modeling	LS-DYNA, OpenSees, SAP2000; nonlinear static and dynamic analysis
Probabilistic methods	Fragility analysis, Bayesian updating (MCMC), uncertainty quantification, global sensitivity analysis
Programming	Python, MATLAB
Digital media	Educational video production; interactive web simulations
Languages	Haitian Creole (native), French (native), English (fluent), Spanish (limited)