

Edvard P.G. Bruun

Curriculum Vitae

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EDUCATION

- 2019 - 2023 **PhD**, *Civil and Environmental Engineering Department*, Princeton University.
(ABD) Dissertation: Graph-Based Design Methods for the Scaffold-Free Cooperative Robotic Assembly and Disassembly Planning of Discrete Element Spatial Structures
Advisors: Dr. Sigrid Adriaenssens & Dr. Stefana Parascho
CGPA: 4.00/4.00
- 2015 - 2017 **MASc**, *Department of Civil and Mineral Engineering*, University of Toronto.
Thesis: The Hybrid Panel-Truss Element: Developing a Novel Finite Element for the Nonlinear Analysis of Reinforced Concrete Beams and Shells.
Repository: <http://hdl.handle.net/1807/79117>
Advisors: Dr. Evan Bentz & Dr. Oh-Sung Kwon
CGPA: 4.00/4.00
- 2010 - 2015 **BASc**, *Department of Civil and Mineral Engineering*, University of Toronto.
Thesis: Investigating the Compressive Behaviour of Glass Fibre Reinforced Polymer Bars.
Advisor: Dr. Shamim Sheikh
CGPA: 3.88/4.00 (Dept. Rank = #1/140)

PUBLICATIONS

Peer-Reviewed Journal Articles

- 2022 **E.P.G. Bruun**, S. Adriaenssens, S. Parascho, "Structural rigidity theory applied to the scaffold-free (dis)assembly of space frames using cooperative robotics," *Automation in Construction*. 141, p. 104405. DOI: <https://doi.org/10.1016/j.autcon.2022.104405>
- 2022 **E.P.G. Bruun**, E.C. Bentz, "A mechanics-based finite element for the analysis of shear-critical slender reinforced beams and columns," *Journal of Structural Engineering*. 148(9), p. 04022142. DOI: [https://doi.org/10.1061/\(ASCE\)ST.1943-541X.0003424](https://doi.org/10.1061/(ASCE)ST.1943-541X.0003424)
- 2021 **E.P.G. Bruun**, R. Pastrana, V. Paris, A. Beghini, A. Pizzigoni, S. Parascho, and S. Adriaenssens, "Three cooperative robotic fabrication methods for the scaffold-free construction of a masonry arch," *Automation in Construction*, 129, p. 103803. DOI: <https://doi.org/10.1016/j.autcon.2021.103803>
- 2020 S. Parascho, I.X. Han, S. Walker, A. Beghini, **E.P.G. Bruun**, and S. Adriaenssens, "Robotic vault: A cooperative robotic assembly method for brick vault construction," *Construction Robotics*, 4(3), pp. 117-126. DOI: <https://doi.org/10.1007/s41693-020-00041-w>
- 2020 **E.P.G. Bruun**, I. Ting, S. Adriaenssens, S. Parascho, "Human-robot collaboration: A fabrication framework for the sequential design and construction of unplanned spatial structures," *Digital Creativity*, 31(4), pp. 320-336. DOI: <https://doi.org/10.1080/14626268.2020.1845214>

- 2020 **E.P.G. Bruun**, A. Kuan, E.C. Bentz, "How to Model Post-Cracking Torsional Stiffness and Why It Matters in Design," *Examples for the Design of Reinforced and Prestressed Concrete Members Under Torsion*, American Concrete Institute SP-344, pp. 49-63. DOI: <https://doi.org/10.14359/51728290>
- 2020 A. Kuan, **E.P.G. Bruun**, E.C. Bentz, and M.P. Collins, "Alternative Design Procedures for Torsion in ACI 318-19: A Comparative Study," *Examples for the Design of Reinforced and Prestressed Concrete Members Under Torsion*, American Concrete Institute SP-344, pp. 64-91. DOI: <https://doi.org/10.14359/51728291>
- 2019 A. Kuan, **E.P.G. Bruun**, E.C. Bentz, and M.P. Collins, "Nonlinear sectional analysis of reinforced concrete beams and shells subjected to pure torsion," *Computers & Structures*, 222, pp. 118-132. DOI: <https://doi.org/10.1016/j.compstruc.2019.07.001>
- 2018 **E.P.G. Bruun**, and A. Duka, "Artificial Intelligence, Jobs and the Future of Work: Racing with the Machines," *Basic Income Studies Journal*, 13(2), p. 20180018. DOI: <https://doi.org/10.1515/bis-2018-0018>
- 2014 **E.P.G. Bruun**, "GFRP Bars in Structural Design: Determining the Compressive Strength versus the Unbraced Length Interaction Curve," *The Journal of Student Science and Technology*, 2014(1), pp. 22-29. DOI: <https://doi.org/10.13034/cysj-2014-003>

Peer-Reviewed Conference Proceedings

- 2022 **E.P.G. Bruun**, E. Besler, S. Adriaenssens, S. Parascho, "ZeroWaste: Towards the robotic disassembly and reuse of conventional timber stick frame structures," *Proceedings of the 42nd Annual Conference of the Association for Computer Aided Design in Architecture*, ACADIA 2022: Hybrids & Haecceities. Philadelphia, PA. Proceedings Link: TBD
- 2021 V. Paris, N. Lepore, **E.P.G. Bruun**, G. Ruscica, M.D. Piccioni, A. Beghini, S. Parascho, and S. Adriaenssens, "Robotic construction of a self-balancing glass masonry vault: DEM study of stability during construction stages," *Proceedings of the International Conference on Spatial Structures*, IASS 2020/21: Inspiring the Next Generation, pp. 314-325. Surrey, England. Proceedings Link: <https://doi.org/10.15126/900337>
- 2020 S. Parascho, I.X. Han, A. Beghini, M. Miki, S. Walker, **E.P.G. Bruun**, and S. Adriaenssens, "LightVault: A design and robotic fabrication method for complex masonry structures," *Advances in Architectural Geometry*, AAG 2020, pp. 350-375. [online due to COVID]. Proceedings Link: https://thinkshell.fr/wp-content/uploads/2019/10/AAG2020_18_Parascho.pdf
- 2020 I.X. Han, **E.P.G. Bruun**, S. Marsh, S. Adriaenssens, and S. Parascho, "From concept to construction: A transferable design and robotic fabrication method for a building-scale vault," *Proceedings of the 40th Annual Conference of the Association for Computer Aided Design in Architecture*, ACADIA 2020: Distributed Proximities, pp. 614-623. [online due to COVID]. Proceedings Link: http://papers.cumincad.org/cgi-bin/works/Show?acadia20_614
- 2018 **E.P.G. Bruun**, A. Kuan, G.T. Proestos, E.C. Bentz, and M.P. Collins, "Advanced Nonlinear Finite Element Modelling of Reinforced Concrete Bridge Piers," *Proceedings from the 9th International Conference on Bridge Maintenance, Safety and Management*, IABMAS 2018. Melbourne, Australia. Proceedings Link: <https://www.crcpress.com/Maintenance-Safety-Risk-Management-and-Life-Cycle-Performance-of-Bridges/Powers-Frangopol-Al-Mahaidi-Caprani/p/book/9781138730458>

- 2017 **E.P.G. Bruun**, and E.C. Bentz, "Experimental Procedures for Displacement-Controlled Pure Torsion Tests on Reinforced Concrete Shells," *Proceedings from the 7th International Conference on Advances in Experimental Structural Engineering*, TAESE. Pavia, Italy.
Proceedings Link: <http://7aese.eucentre.it/index.php/all-documents/>
- 2017 **E.P.G. Bruun**, O. Kovaleva, and K. Peterson, "Microstructural Characterization of Historic Vitrified Paving Brick from the Streets of Sofia," *Proceedings from the 13th Canadian Masonry Symposium*, CMS. Halifax, Nova Scotia. Proceedings Link: <https://www.canadamasonrydesigncentre.com/symposiums/13th-canadian-masonry-symposium/13th-cms/>
- 2014 **E.P.G. Bruun**, "Robert Maillart: The Evolution of Reinforced Concrete Bridge Forms," *Proceedings from the 9th International Conference on Short and Medium Span Bridges*, SMSB 2014, pp. 588-596. Calgary, Alberta. Proceedings Link: <http://www.proceedings.com/40107.html>
- 2014 **E.P.G. Bruun**, and S. Sheikh, "GFRP Bars as Compressive Reinforcement in Exposed Structures," *Proceedings from the 9th International Conference on Short and Medium Span Bridges*, SMSB 2014, pp. 1174-1182. Calgary, Alberta. Proceedings Link: <http://www.proceedings.com/40107.html>

Technical Reports

- 2023 (in press) A. Mazurek, J. Tobolski, O. Amir, S. Saadat, O. Lavan, **E.P.G. Bruun**, "Charts for efficient design of spanning trusses," *Task Committee for the Efficient Design of Spanning Trusses*, Structural Engineering Institute (SEI) of the American Society of Civil Engineers (ASCE). Report Link: TBD

Conference Presentations

- 2023 (accepted) R. Oval, W. Al Asali, **E.P.G. Bruun**, S. Adriaenssens, "From historical scaffold-free masonry vault construction to future structural forms and patterns," *13th edition of the International Conference on Structural Analysis of Historical Constructions*, SAHC 2023. Kyoto, Japan.
- 2022 **E.P.G. Bruun**, S. Adriaenssens, S. Parascho, "Fabrication-informed structural design: Graph theoretic approaches for the robotic assembly and disassembly sequence planning of discrete element structures," *Structural Engineering Institute of ASCE Annual Conference*, Structures Congress 2022. Atlanta, Georgia.
- 2020 S. Parascho, I.X. Han, S. Walker, A. Beghini, **E.P.G. Bruun**, and S. Adriaenssens, "Robotic Vault: A Cooperative Robotic Assembly Method for Compression-Only Vault Construction," *Rob|Arch 2020: On-Site Robotics*. [cancelled due to COVID].
- 2018 A. Kuan, and **E.P.G. Bruun**, "A Cross-Platform Approach for the Seismic Performance Assessment of a Shear Critical RC Frame," *11th U.S. National Conference on Earthquake Engineering*, 11NCEE. Los Angeles, California.

Non-Peer Reviewed Writing

- 2021 **E.P.G. Bruun**, S. Parascho, and S. Adriaenssens, "Generative Design." In P. L. Frana & M. J. Klein (Eds.), *Encyclopedia of Artificial Intelligence: The Past, Present, and Future of AI*. ABC-CLIO. ISBN: 978-1-4408-5326-5, Link: <https://www.abc-clio.com/products/a5303c/>
- 2021 **E.P.G. Bruun**, A. Duka, "Workplace Automation." In P. L. Frana & M. J. Klein (Eds.), *Encyclopedia of Artificial Intelligence: The Past, Present, and Future of AI*. ABC-CLIO. ISBN: 978-1-4408-5326-5, Link: <https://www.abc-clio.com/products/a5303c/>

HONORS AND AWARDS

Competitive Research Funding

- 2020 - 2022 **Princeton Catalysis Initiative**, 2 x \$30,000 (*full stipend*), Princeton University.
Contributed to the submission of the proposal "Fabrication-Informed Design: Building Efficient Structures with Cooperative Robotic Fabrication Methods"
- 2019 - 2022 **Alexander Graham Bell Graduate Scholarship**, 3 x \$35,000, Doctoral Program (CGS-D), Natural Sciences and Engineering Research Council (NSERC) of Canada.
- 2016 - 2017 **Queen Elizabeth II Graduate Scholarship in Science & Technology**, \$15,000, Master's Program (QEII-GSST), Provincial Government of Ontario.
- 2015 - 2016 **Alexander Graham Bell Graduate Scholarship**, \$17,500, Master's Program (CGS-M), Natural Sciences and Engineering Research Council (NSERC).
- 2012 / 2013 **Undergraduate Student Research Award**, 2 x \$6,000, Natural Sciences and Engineering Research Council (NSERC) of Canada.

Academic Awards & Fellowships

- 2022 **SEI Structures Congress Scholarship**, American Society of Civil Engineers.
- 2022 **Research Grant**, Structural Engineers Foundation (SEF), Structural Engineers Association of Illinois (SEAol).
- 2022 **Conference Travel Grant**, School of Engineering and Applied Science, Princeton University.
- 2021 **Graduate Scholarship**, Structural Engineers Foundation (SEF), Structural Engineers Association of Illinois (SEAol).
- 2019 - 2024 **Francis Robbins Upton Fellowship**, School of Graduate Studies, Princeton University.
- 2019 **Daniel W. Falconer Memorial Fellowship**, \$15,000, American Concrete Institute (ACI).
- 2017 **Conference Grant**, School of Graduate Studies, University of Toronto.
- 2015 - 2017 **Graduate Fellowship**, School of Graduate Studies, University of Toronto.
- 2013 **Leadership Award**, Faculty of Engineering, University of Toronto.
- 2012 **5T6 Civils Scholarship**, Department of Civil Engineering, University of Toronto.
- 2010 **Tanenbaum Admissions Scholarship**, Department of Civil Engineering, University of Toronto.

Miscellaneous Awards and Honors

- 2021 **R+D Award**, *Architect Magazine*, American Institute of Architects,
Role: researcher in CREATE Laboratory and Form Finding Lab.
https://www.architectmagazine.com/awards/r-d-awards/award-robotic-constructionthe-glass-vault_o
- 2021 **Best Special Structure**, *Excellence in Structural Engineering Awards*, Structural Engineers Association of Illinois (SEAol),
Role: researcher in CREATE Laboratory and Form Finding Lab.
<https://www.seaoi.org/excellence-structural-engineering-awards>

- 2021 **Top 4 Finalist**, *Structural Awards - Structural Artistry (non building structures)*, The Institution of Structural Engineers (IStructE),
Role: researcher in CREATE Laboratory and Form Finding Lab.
[https://www.istructe.org/structuralawards/the-shortlist/structural-artistry-\(non-buildings\)](https://www.istructe.org/structuralawards/the-shortlist/structural-artistry-(non-buildings))
- 2018 **Gordon Cressy Student Leadership Award**, *Alumni Association*, University of Toronto.
<https://alumni.utoronto.ca/events-and-programs/awards/gordon-cressy-student-leadership-award/recipient/2018/edvard-bruun>
- 2018 **Grads to Watch**, *Faculty of Engineering*, University of Toronto.
<http://news.engineering.utoronto.ca/engineering-grads-to-watch-2018-feature/>
- 2017 **Top 20 Finalist**, *Science, Action! Video Contest*, Natural Sciences and Engineering Research Council of Canada (NSERC), https://www.youtube.com/watch?v=_xUv_tCbvyk .
- 2015 **W.S. Wilson Medal**, *Faculty of Engineering*, University of Toronto.
Awarded to the graduating undergraduate student with the highest cumulative course grade average in their respective department.
- 2013 **First Place: Consulting Competition**, *Ontario Engineering Competition (OEC)*, 34th Annual.
<http://alumni.engineering.utoronto.ca/news/u-of-t-students-shine-at-the-2013-ontario-engineering-competition/>

Media Mentions (as researcher in CREATE Laboratory and Form Finding Lab)

- 2022 **Princeton University**, *Office of Engineering Communications*, Building bots could brave harsh environments, create new types of structures, <https://engineering.princeton.edu/news/2022/01/25/building-bots-could-brave-harsh-environments-create-new-types-structures>.
- 2020 **Princeton University**, *Office of Communication*, Robots and humans collaborate to revolutionize architecture, <https://www.princeton.edu/news/2020/10/21/robots-and-humans-collaborate-revolutionize-architecture>.
- 2020 **3D Printing Media Network**, Princeton researchers create glass LightVault using robots, <https://www.3dprintingmedia.network/princeton-researchers-create-breathtaking-glass-lightvault-using-robots/>.
- 2020 **Tech XPlore**, Robots and humans collaborate to revolutionize architecture, <https://techxplore.com/news/2020-10-robots-humans-collaborate-revolutionize-architecture.html>.
- 2020 **Skidmore, Owings & Merrill (SOM)**, Robotic Construction: The Glass Vault, <https://www.som.com/research/robotic-construction-the-glass-vault/>.
- 2020 **Parametric House**, Glass Vault, <https://parametrichouse.com/glass-vault/>.
- 2020 **Primante 3D**, Des chercheurs utilisent des robots pour fabriquer une voûte en briques de verre, <https://www.primante3d.com/briques-verre-231102020/>.

WORK EXPERIENCE

Professional

- 2017 - 2019 **Structural Engineer**, *Building Structures Group*, Arup Canada Inc.
- Design of: Pier G for Toronto's Pearson Airport, Canadian Canoe Museum, Molson Amphitheater VIP viewing deck, Confederation Line LRT extension (bid package)
- 2013 - 2014 **Structural Design Intern**, *Building Structures Group*, Arup Canada Inc.
- Design and structural coordination of client initiated design changes, and site inspections for the Billy Bishop Pedestrian Tunnel in Toronto

Research

- 2019 - present **Graduate Student**, *Department of Civil and Environmental Engineering*, Princeton University.
- Evaluated the structural impact of various cooperative robotic assembly approaches for a scaffold-free masonry arch as part of a doubly-curved vault
 - Developed a "design-as-you-build" interactive framework for human-robot collaboration
 - Used rigidity theory to plan space frame structures that can remain stable during all phases of robotic (dis)assembly
 - Stitched together 3D point cloud scans of a large-scale timber-framed structure and using this "as-built" information to inform a robotic disassembly and reconfiguration sequence
- 2015 - 2017 **Graduate Student**, *Department of Civil Engineering*, University of Toronto.
- Performed the world's first pure torsion tests on two large-scale reinforced concrete shells
 - Experimental research using the state-of-the-art 60-actuator Shell Element Tester, the results of which were included in the submitted master's thesis
 - Developed a displacement-controlled testing protocol that allowed for the collection of stable post-peak experimental data
 - Developed a novel finite element for the general analysis of reinforced concrete beams and shells
- 2017 **Research Assistant**, *M.P. Collins and Associates*.
- Contributed finite element modelling results to the expert testimony and written reports on the strut-and-tie modelling of cracked reinforced concrete bridge piers in Nova Scotia
 - Contributed to the derivation of the general compatibility torsion relationship for a prestressed concrete beam-slab system
- 2011 - 2013 **Undergraduate Research Assistant**, *Department of Civil Engineering*, University of Toronto.
- Assisted Professor Shamim Sheikh's research group with the construction of columns with internal Glass Fiber Reinforced Polymer (GFRP) bars
 - Planned and executed independent experiments on the compressive behavior of GFRP bars, the results of which were included in the submitted undergraduate thesis

Teaching

- 2020 / 2022 **Teaching Assistant**, *Mechanics of Solids*, CEE205, Princeton University.
- Prepared and taught weekly two-hour tutorial sessions
 - Adapted to online teaching halfway through the term due to COVID (in 2020)
- 2016 - 2018 **Course Instructor**, *Mechanics*, CIV100, University of Toronto.
- Fall Terms
- Prepared and conducted three hours of lectures per week for a class of 100 students
 - Supervised two teaching assistants in the planning of the two-hour weekly tutorials

- 2016 / 2017 **Teaching Assistant**, *Finite Element Methods in Structural Mechanics*, CIV1174, University of Toronto.
Spring Terms
- Graduate level course on the mathematical formulation of finite element analysis techniques
 - Prepared and marked weekly assignments, and taught a weekly one-hour tutorial session
- 2016 / 2017 **Teaching Assistant**, *Mechanics and Materials*, CIV102, University of Toronto.
Fall Terms
- Taught a weekly two-hour tutorial for a class of 30 students
 - Lectured, administered weekly quizzes, and ran bi-weekly laboratory experiments

SERVICE

Workshops and Seminars

- 2021 - present **Research Seminar Series**, *Department of Civil and Environmental Engineering*, Princeton University.
- Created and organized a new bi-weekly departmental seminar series for students and professors
- 2020 - present **ROBELARCH: Global Collaborative Network**, Princeton University.
- Global research network with 20+ academic and industry members across 10+ organizations
 - Main organizer and facilitator for the network events and international exchanges
- 2021 **Workshop Leader**, *Remote Robotic Assemblies*, ACADIA Conference.
- Partnered with a team from ETH Zurich, Gramazio Kohler Research, to host a 3-day workshop on remote robotic fabrication using the COMPAS framework
 - 15 participants from 7 countries sent remote instructions to the robots in the Princeton lab for the cooperative assembly of a geometrically complex space frame arch

Academic and Professional Committees

- 2022 - present **Member**, *Student Initiatives Committee*, Structural Engineering Institute (SEI), American Society of Civil Engineers (ASCE).
- A committee dedicated to promoting student involvement in the SEI and Structures Congress
- 2021 - present **Member**, *Efficient Design of Spanning Trusses Task Committee*, Structural Engineering Institute (SEI), American Society of Civil Engineers (ASCE).
- A special task group formed from the Optimal Structural Design (OSD) committee dedicated to the publication of a comprehensive report on the optimal design of truss structures
- 2020 - present **Member**, *Optimal Structural Design (OSD) Committee*, Structural Engineering Institute (SEI), American Society of Civil Engineers (ASCE).
- A technical committee for the dissemination of new developments related to the development of the state-of-the-art of optimal design of structures
- 2020 - 2021 **Member**, *Communications Committee*, International Association for Shell and Spatial Structures (IASS).
- A student team dedicated to improving the online presence of the organization
- 2016 - 2017 **Voting Member**, *Academic Board*, Governing Council, University of Toronto.
- The Academic Board votes on matters that affect the teaching, learning, and research functions of the whole university
- 2016 - 2017 **Voting Member**, *Planning and Budget Committee*, Governing Council, University of Toronto.
- The Planning and Budget Committee is responsible for monitoring and reviewing the use of university resources spent on capital projects for the whole university

Journal and Conference Paper Reviewer

Journals **Automation in Construction, Engineering Structures, Computer-Aided Design.**

Conferences **ACADIA.**

Student Organizations

2021 - present **President**, *Graduate Engineering Council*, Princeton University.

- Organized monthly social events for all graduate students in the Faculty of Engineering
- Facilitated open town hall discussions with the dean each term

2016 - 2017 **Administrative Director**, *ILead:Grad*, University of Toronto.

- Organized monthly events focused on networking and the development of professional skills for the whole graduate student body

2015 - 2017 **Vice President**, *Graduate Chapter*, Earthquake Engineering Research Institute, University of Toronto.

- Founded the University of Toronto graduate chapter of the EERI organization.
- Organized lectures and brought in speakers to further graduate knowledge of seismic engineering

PROFESSIONAL AFFILIATIONS

2019 - present **Professional Engineer (P.Eng.)**, #100226968, Professional Engineers Ontario (PEO).

2019 - present **Student Member (S.M.ASCE)**, #11931180, American Society of Civil Engineers (ASCE).

2019 - present **Student Member**, #11931180, Structural Engineering Institute (SEI).

2019 - present **Student Member**, #53514340, International Association for Shell and Spatial Structures (IASS).

2015 - present **Student Member**, #1339486, American Concrete Institute, ACI.

REFERENCES

Sigrid Adriaenssens, Ph.D.

Professor & Director of Program in Mechanics, Materials and Structures,
Department of Civil and Environmental Engineering

Form Finding Lab: <http://formfindinglab.princeton.edu/>

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School of Architecture, Civil and Environmental Engineering (ENAC)

Lab for Creative Computation: <https://www.epfl.ch/labs/crccl/>

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