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Ing. Marek Tyburec, PhD

Postdoc @UTIA CAS @FCE CTU in Prague

Profiessional interests: topology optimization, numerical optimization, mathematical modeling, computational mechanics, fiber-reinforced composites, additive manufacturing, polynomial optimization

Research and professional activities

2022→ **Postdoc @Institute of Information Theory and Automation, Czech Academy of Sciences**
Topology optimization

2022→ **Postdoc @Faculty of Civil Engineering, Czech Technical University in Prague**
Polynomial optimization of bending-resistant structures
Modular-topology optimization

2017–2021 **PhD candidate @OpenMechanics group, Faculty of Civil Engineering, Czech Technical University in Prague**
Optimum design of wound composite beam internal structures
Optimum design of modular (meta)materials, structures and mechanisms
Polynomial optimization of bending-resistant structures
Wang tiling

9/2018–2/2019 **FemCAD solutions**
Optimization of modular frame structures with discrete cross sections

9/2018–1/2019 **1to1design**
Structurally optimized design of a wheelchair frame for disabled children

Education

2017–2021 **Faculty of Civil Engineering, Czech Technical University in Prague**
Doctoral degree program: Civil Engineering–Physical and Materials Engineering
Thesis: Modular-topology optimization of structures and mechanisms
Supervisors: Prof. Jan Zeman, Dr. Matěj Lepš
Opponents: Prof. Jean-Bernard Lasserre, Prof. Michal Kočvara

2015–2017 **Faculty of Civil Engineering, Czech Technical University in Prague**
Master degree program: Civil Engineering–Building Structures
Thesis: Modular-topology optimization of truss structures composed of Wang tiles
Supervisor: Prof. Jan Zeman

2011–2015 **Faculty of Civil Engineering, Czech Technical University in Prague**
Bachelor degree program: Civil Engineering–Building Structures
Thesis: Multi-objective optimization of proton therapy treatment plan
Supervisor: Dr. Matěj Lepš

Teaching

2022–2023	Structural optimization (lectures, in Czech, 3 semester courses)
2017–2019	Numerical Analysis of Structures (exercise sessions, in English, 3 semester courses)
2018–2021	Structural Mechanics 1 (exercise sessions, in Czech, 4 semester courses)
2018–2021	Structural Mechanics 2 (exercise sessions, in Czech, 4 semester courses)

Skills and competences

- Advanced knowledge: BASH, C++, MATLAB, LaTeX, Ansys APDL, Scia Engineer, CPLEX, Gurobi, MOSEK, Autodesk AutoCAD, Microsoft Office, LibreOffice, HTML, CSS
- Basic knowledge: Python, MeshLab, Blender, PHP
- Languages: English (B2–First Certificate in English), Czech (native), German (B1)

Awards and achievements

- Best Junior Paper Award 2023 for the paper "Bounded Wang tilings with integer programming and graph-based heuristics" awarded by Institute of Information Theory and Automation
- Joseph Fourier Prize for Computer Sciences 2022 – Special Prize IT4Innovations awarded by Embassy of France in the Czech Republic, Atos and IT4Innovations
- Prof. Babuška honorable mention for excellent work in computational sciences for doctoral thesis
- Rector's Prize 2021 for an outstanding doctoral dissertation
- Nomination for the JEC2019 Innovation Awards in the additive manufacturing category for the Optimised 3D-printed internal beam structure (third place)
- Named acknowledgment in Donald Knuth's *The Art of Programming, Volume 4, Fascicle 5c: Dancing Links* for discovering a redundant tile in Knuth's aperiodic tile set of 92 tiles, which was originally published within *The Art of Programming, Volume 1: Fundamental Algorithms* in 1968
- Prof. Babuška honorable mention for excellent work in computational sciences for diploma thesis
- Prof. Bechyně Prize for the best diploma thesis in the Theory of Structures and Materials Engineering category
- Dean's honorable mention for excellent elaboration and defense of diploma thesis
- Dean's honorable mention for excellent elaboration and defense of bachelor thesis
- Winner of the SVOČ 2015 Student Research and Professional Activities competition in the field of structural mechanics

Journal articles

- M. Tyburec, M. Kočvara, M. Handa, and J. Zeman, Global weight optimization of frame structures under free-vibration eigenvalue constraints, 2024, doi: 10.13140/RG.2.2.32834.39365 [preprint]
- M. Handa, M. Tyburec, and M. Kočvara, Term-sparse polynomial optimization for the design of frame structures, 2024, doi: 10.13140/RG.2.2.21116.55681 [preprint]
- S. Ma, J. Mareček, V. Kungurtsev, and M. Tyburec, Truss topology design under harmonic loads: Peak power minimization with semidefinite programming, 2024, arXiv: 2401.16175 [preprint]
- M. Tyburec, M. Doškář, M. Somr, M. Kružík, and J. Zeman, Modular-topology optimization for additive manufacturing of reusable mechanisms, 2023a, doi: 10.13140/RG.2.2.29545.26724 [preprint]

- M. Tyburec, M. Kočvara, and M. Kružík, Global weight optimization of frame structures with polynomial programming, *Structural and Multidisciplinary Optimization*, 66(12):257, 2023b, doi: 10.1007/s00158-023-03715-5
- M. Tyburec and J. Zeman, Bounded Wang tilings with integer programming and graph-based heuristics, *Scientific Reports*, 13(1), 2023, doi: 10.1038/s41598-023-31786-3
- M. Tyburec, M. Doškář, J. Zeman, and M. Kružík, Modular-topology optimization of structures and mechanisms with free material design and clustering, *Computer Methods in Applied Mechanics and Engineering*, 395:114977, 2022a, doi: 10.1016/j.cma.2022.114977
- M. Tyburec, J. Zeman, M. Kružík, and D. Henrion, Global optimality in minimum compliance topology optimization of frames and shells by moment-sum-of-squares hierarchy, *Structural and Multidisciplinary Optimization*, 64(4):1963–1981, 2021b, doi: 10.1007/s00158-021-02957-5
- M. Tyburec, J. Zeman, M. Doškář, M. Kružík, and M. Lepš, Modular-topology optimization with Wang tilings: An application to truss structures, *Structural and Multidisciplinary Optimization*, 63(3):1099–1117, 2020a, doi: 10.1007/s00158-020-02744-8
- M. Tyburec, J. Zeman, J. Novák, M. Lepš, T. Plachý, and R. Poul, Designing modular 3D printed reinforcement of wound composite hollow beams with semidefinite programming, *Materials & Design*, 183: 108131, 2019b, doi: 10.1016/j.matdes.2019.108131

Invited talks

- M. Tyburec and R. Poul, Optimized 3D-printed internal structure of CFRP beams, Workshop Mathematics in Industry, Institute of Mathematics, Czech Academy of Sciences, 2021
- M. Tyburec, Global optimality in minimum-compliance topology optimization by moment-sum-of-squares hierarchy, MA4M: Mathematical analysis for mechanics, online, 2020b
- M. Tyburec, Topology optimization of discrete structures by semidefinite programming, Optimisation and numerical analysis seminar, University of Birmingham, 2019a
- M. Tyburec, Topology optimization of discrete structures by semidefinite programming, Nečas seminar of continuum mechanics, Faculty of Mathematics and Physics, Charles University, 2019b

Conferences and abstracts

- M. Tyburec, Global minimum-weight design of frame structures with polynomial optimization, In *The 15th World Congress of Structural and Multidisciplinary Optimization, Book of Abstracts*. International Society for Structural and Multidisciplinary Optimization, 2023
- M. Tyburec, M. Doškář, J. Zeman, and M. Kružík, Modular-topology optimization of structures and mechanisms: A free-material optimization-based heuristics, ECCOMAS 2022, Oslo, Norway, 2022b
- M. Tyburec, J. Zeman, M. Kružík, and D. Henrion, Topology optimization of discrete structures by polynomial optimization, EurOpt 2021, Ecole Nationale de l'Aviation Civile, Toulouse, France, 2021c, [link]
- M. Tyburec, J. Zeman, M. Kružík, and D. Henrion, Global optimality in minimum compliance topology optimization of frame and shell structures, In *The 14th World Congress of Structural and Multidisciplinary Optimization, Book of Abstracts*. International Society for Structural and Multidisciplinary Optimization, 2021d
- M. Tyburec, J. Zeman, M. Kružík, and D. Henrion, Global minimum-compliance optimization of frame and shells, VI ECCOMAS Young Investigators Conference, Valencia, Spain, 2021e
- M. Tyburec, Robotická "stavebnice": Navíjené kompozitní nosníky, *Tecnicall*, 01:32, 2020a, [link]
- M. Tyburec, J. Zeman, M. Kružík, and D. Henrion, On optimum design of frame structures, In *NMM2019: Nano & Macro Mechanics 2019*, volume 26, page 117–125, Prague, 2020b. Czech Technical University in Prague, doi: 10.14311/app.2020.26.0117

- M. Tyburec, J. Zeman, J. Novák, M. Lepš, T. Plachý, and R. Poul, 3D-printed internal structure for composite beams by semidefinite programming, In *ISCAMI 2019, Book of Abstracts*, Prague, 2019c. Czech Technical University in Prague, Faculty of Civil Engineering
- M. Tyburec, J. Zeman, J. Novák, and R. Poul, Optimised 3D-printed internal beam structure, *JEC Composites Magazine*, 56(127):115, 2019d
- M. Tyburec and R. Poul, Vnitřní struktury navíjených kompozitních nosníků, *Pražská technika*, 01:14, 2019, [link]
- M. Tyburec, J. Zeman, and M. Lepš, Optimization of modular truss structures composed of Wang tiles, In *The 13th World Congress of Structural and Multidisciplinary Optimization, Book of Abstracts*. International Society for Structural and Multidisciplinary Optimization, 2019a
- M. Tyburec, J. Zeman, M. Lepš, J. Novák, and R. Poul, Wound composite beam internal structure optimization, In *Engineering Mechanics 2018, Book of Full Texts*, page 873–876, Prague, 2018a. Institute of Theoretical and Applied Mechanics, Czech Academy of Sciences, doi: 10.21495/91-8-873
- M. Tyburec, J. Zeman, M. Lepš, M. Somr, T. Plachý, J. Novák, and R. Poul, Minimum-weight truss reinforcement of a composite beam to increase the free-vibrations fundamental eigenfrequency, In *Special Concrete and Composites 2017*, volume 760 of *Key Engineering Materials*, page 219–224, Zürich, 2018b. Transtech Publications, doi: 10.4028/www.scientific.net/KEM.760.219
- M. Tyburec and J. Zeman, Optimization-based approach to tiling finite areas with arbitrary sets of Wang tiles, In *NMM2017: Nano & Macro Mechanics 2017*, volume 13, page 135–141, Prague, 2017b. Czech Technical University in Prague, doi: 10.14311/APP.2017.13.0135
- M. Tyburec and J. Zeman, Comparison of semidefinite solvers for topology optimization of cantilever trusses subject to fundamental eigenvalue constraint, In *Modern Methods of Experimental and Computational Investigations in Area of Construction II*, page 172–177, Pfaffikon, 2017a. Transtech Publications, doi: 10.4028/www.scientific.net/AMR.1144.172
- M. Tyburec and M. Lepš, Global topology weight optimization of 52-bar benchmark truss with discrete cross-sections, In *Engineering Mechanics 2016, Book of Full Texts*, page 558–561, Prague, 2016. Institute of Theoretical and Applied Mechanics, Czech Academy of Sciences

Poster presentations

- M. Tyburec, M. Doškář, J. Zeman, and M. Kružík, Modular-topology optimization with Wang tilings: Free-material-optimization-based heuristics, GAMM Junior's Summer School 2021 on Shape and Topology Optimization, Austria, Graz, 2021a
- M. Tyburec, J. Zeman, M. Doškář, M. Lepš, and J. Novák, Modular-topology optimization of truss structures composed of Wang tiles, Topology optimization: Theory, methods, and applications, Denmark, Copenhagen, 2017

Service to the community

2023	Review for Theoretical Computer Science
2023	Referee of diploma thesis Dominik Fischer, Control system for morphing lattice-based structures Faculty of Electrical Engineering, Czech Technical University in Prague
2021	Review for Composites Part B: Engineering
2021	Chairman of an invited stream Polynomial Optimization I at the EurOpt2021 conference
2020	Review for Engineering Computations
2019	Referee of diploma thesis Lukáš Bertl, Self-assembly: Modelling, simulation, and planning Faculty of Electrical Engineering, Czech Technical University in Prague

Professional training

- Topology optimization: Theory, methods, and applications (Denmark, DTU, 2017)
- Summer school of mechanics of composite materials and structures (Czech Republic, 2017)
- Linear matrix inequalities with applications in control (Faculty of Electrical Engineering, CTU in Prague, 2018)
- Combinatorial optimization (Faculty of Electrical Engineering, CTU in Prague, 2018)
- Numerical optimization (Faculty of Mathematics and Physics, Charles University, 2018)
- Modeling of localized inelastic deformation (Faculty of Civil Engineering, CTU in Prague, 2018)
- Mechanics of composite materials (Faculty of Mechanical Engineering, CTU in Prague, 2018)
- Micromechanics and description of material microstructure (Faculty of Civil Engineering, CTU in Prague, 2018)
- Numerical methods in mechanics 1 and 2 (Faculty of Civil Engineering, CTU in Prague, 2017–2018)
- OOFEM training course (Faculty of Civil Engineering, CTU in Prague, 2018)
- Scientific writing (National Library of Technology, 2018)
- GAMM junior's summer school 2021 on shape and topology optimization (Graz, Austria, 2021)

Funding records

- MŠMT 8J24DE005 Free-material optimization for manufacturable modular structures, mobility support project (Czech Republic, Germany), principal investigator
- GAČR 22-15524S Polynomial optimization in the design of globally optimal frame structures under dynamic loads, project team member
- GAČR 21-06569K Scales and shapes in continuum thermomechanics, project team member
- Initiation fund, scholarship awarded by Faculty of Civil Engineering, CTU in Prague (amount granted 40 000 CZK)
- SGS 21/039/OHK1/1T/11 Global optimality in minimum-compliance topology optimization of frames and shells: Undamped harmonic vibrations, principal investigator of internal student CTU project (amount granted 126 000 CZK)
- SGS 19/033/OHK1/1T/11 Design toolchain for modular structures: Accelerated optimization and stochastic analysis, principal investigator of internal student CTU project (amount granted 820 000 CZK)
- GAČR 19-26143X Non-periodic pattern-forming metamaterials: Modular design and fabrication, project team member
- TAČR TH02020420 Hierarchical additive fabrication of composite components with functionally oriented filling, project team member
- Multi-objective optimization of proton therapy treatment plan, scholarship awarded by CTU MediaLab (amount granted 70 000 CZK)

International stays

- Three-week stay at University of Birmingham (Prof. Michal Kočvara)