Parallel Session - Paper Presentations

Monday

Slot 1: 14:00 - 15:30

Room: HIL E3 - WG 12 Timber and Bio-based Spatial Structures

Moderator: **Minjuan He**

63 Mechanical performance and engineering applications of largespan tension-string timber folded plate latticed shell structure
Hua Mao and Jiemin Ding
Keywords: timber folded structure, geometric form, structural efficiency, string arrangement, joint stiffness

556 Compression response of digitally manufactured engineered bamboo spliced hollow columns.
Phillip Russell and **Dan V. Bompa**
Keywords: digital manufacturing, engineered bamboo, dry mechanical connections, disassembly

15 Experiments and Numerical Simulation Investigations on the Mechanical Performance of Glulam Enhanced with Self-Tapping Screws Along Parallel Glue Seam
Jinjiang Zhou, Minjuan He and Jing Luo
Keywords: Reciprocal timber grid shell, Glulam enhanced with self-tapping screws, Mechanical performance

202 Rhipsalis baccifera: a counterintuitive role model for the architectural tectonics of nodeless nodes
Hasan Hadi Abdulameer, Sebastian J. Antreich and Günther H. Filz
Keywords: Architecture, Botany, Biomimetics, Branching, Tectonics, Structures

75 Bending test of nail laminated timber (NLT): From the lamination to the composite panel
Wei Feng, Minjuan He, Hengkun Cai and Zheng Li
Keywords: Nail laminated timber, wood lamination, timber-concrete composite panel, bending test, γ-method

357 A study of internal stiffeners in wooden slab panels obtained by topology optimisation
Jiayi Li, Markus Matthias Hudert and Lars Vabbersgaard Andersen
Keywords: Timber design, Circular design, Topology optimisation, Construction waste, Wooden floor slabs

615 Turning Tree Forks into Structures: An Experimental Analysis of a Minimally Processed Material within the Age of Standardization
Zac Chartrand
Keywords: Tree Fork, Dome, Geodesic, Computational Optimization, Catenary Structure, Shell Structure

Room: HIL E4 - WG 13 Computational Methods

Moderator: **Hazuki Hayashi**

123 Integrating Topology Optimization and Aesthetic Design Preferences through Interactive User-Sketched Input
Gillian Schiffer, Dat Ha and **Josephine Carstensen**
Keywords: topology optimization, human-machine collaboration, interactive design

381 Towards Effective Structural Design Embedding by Prompt Engineering Using Large Language Models
Kam-Ming Mark Tam
Keywords: Design Modelling, Design Comparison, Dimensionality Reduction, Machine Learning, Large Language Model, Embedding

17 Integration of Augmented Reality for Enhanced Visualization and Analysis in Bridge Engineering, Towards Real-Time Optimization in Structural and Architectural Design
Abtin Baghdadi, Fatemeh Salehi Amiri, Carsten Jantzen, Norman Hack and **Harald Kloft**
Keywords: Digital planning, Live analyzing, Augmented reality, On-site, Segmental bridge

249 Constrained shape optimization of grid shells based on deep learning
Andrea Favilli, **Francesco Laccone,** Paolo Cignoni, Luigi Malomo and Daniela Giorgi
Keywords: FreeGrid benchmark, grid shell, form finding, shape optimization, structural design, automatic differentiation, sustainability

508 An Immersive Approach to Learning Structures
Shahin Vassigh and Biayna Bogosian
Keywords: Structures Pedagogy, Immersive Learning, Extended Reality, Artificial Intelligence for Personalized Learning

142 Multi-objective optimization of the large telescope backup structure under wind loading
Hiroaki Kawamura, Chihiro Imamura, Akio Taniguchi, Yoichi Tamura and Toshiaki Kimura
Keywords: Large submillimeter telescope, Multi-objective optimization, Genetic algorithm, Homologous deformation

Room: HIL E6 - WG 17 Historical Spatial Structures

Moderator: **Marisela Mendoza**

35 Lightweight Structures and Architectural Archives: The present living of past heritage knowledge
Juan Gerardo Oliva Salinas, Elisa Drago Quaglia and Susana Ezeta Genis
Keywords: Architecture archives, concrete shells, historical research, experimental laboratory, teaching lightweight structures

40 Model analysis as a method for planning resource-efficient reinforced concrete shells using the example of Ulrich Müther
Baris Wenzel, Benjamin Schmid, Christiane Weber, and Eberhard Möller
Keywords: measurement models, reinforced concrete shells, resource-efficient planning, digital twin

206 Visionary Realism. Designing Sergio Musmeci's Bridge over The Niger River Today
Piermaria Caponi, Giulio Paparella, Fabio Cutroni and Maura Percoco
Keywords: historical design, computational design, conceptual design, structural morphogenesis, digital form-finding, 3d concrete printing, additive manufacturing, fabrication optimization

29 Inverted Domes of Sports Halls in New Belgrade and Nis: Analysis from the Aspect of Structural Art
Miodrag Nestorović, Jelena Milošević, Milijana Živković and Marko Gavrilović
Keywords: structural design, construction technology, structural systems, structural art, historical spatial structures, suspended structures, inverted concrete domes

90 Geometrical appropriateness of Dieste's gaussian vault
Daniel Sang-Hoon Lee
Keywords: Long-span structures, Brick vault, Instability, Buckling, Spatial structures

334 Network analysis and visualization for the history of concrete shells – the case study: Istvan Menyhárd
Orsolya Gaspar and Alexandra E. Kis
Keywords: history of concrete shells, network visualization, social network, data analysis, Gephi, Second World, Istvan Menyhard

412 Rediscovering ecclesiastical architectural gems: Silvio Galizia's unseen concrete thin-shells
Giuseppe Canestrino, Chiara Corinna Galizia, **C. Giovanni Galizia** and Roberta Lucente
Keywords: concrete shell, architectural design, ecclesiastical buildings, construction history

629 Contribution of structural intuition at early conceptual stage in efficient workflow: A precedent study of Oscar Niemeyer
Irem Serefoglu, Luiza Wanderley, Remo Pedreschi and Miguel Pareded Maldonado
Keywords:

Room: HIL E7 - WG 8 Metal Spatial Structures

Moderator: **Lorenzo Raffaele**

138 Modifying the Configuration and Members of Hybrid Cable Dome to mitigate the Progressive Collapse
Karim Abedi, Rasoul Asghari, Mohammadreza Chenaghlou and Behzad Shekastehband
Keywords: Hybrid cable dome, Progressive collapse, Alternate path method, Dynamic analysis, BCM, bracing cables, bottom cables net

248 Assessment of the structural, buildability and sustainability performances of the FreeGrid Design Baseline Gridshells
Lorenzo Raffaele, Luca Bruno, Francesco Laccone, Fiammetta Venuti and Valentina Tomei
Keywords: FreeGrid benchmark, gridshells, performance assessment, stability, sustainability, buildability

163 Topology Optimization Of Gridshells With Reused Elements
Valentina Tomei, Ernesto Grande and Maura Imbimbo
Keywords: gridshell, steel, structural optimization, reused elements

233 Design solutions for the barrel vault FreeGrid Design Baseline Gridshell
Luca Bruno, Lorenzo Raffaele and **Fiammetta Venuti**
Keywords: FreeGrid benchmark, gridshells, barrel vault, design solutions, performance assessment

11 Reliable Experimental Testing Methodology for Reciprocal Structures
Martin Steinmetz, Pierre Latteur and Luca Sgambi
Keywords: Reciprocal plane structure, Experimental testing, Structural behaviour

261 FreeGrid benchmark: focusing on sustainability for overall performance enhancement of gridshells
Fabrizio Ascione, Francesco Esposito, Diana Faiella, Valentina Tomei, Maura Imbimbo and Elena Mele
Keywords: FreeGrid benchmark, gridshells, design solutions, performance assessment, sustainability, steel element reuse

43 Super-long span aluminum alloy mega-latticed structures
Qingwen Zhang, Yilinke Tan, Guolong Zhang, Yu Zhang and Feng Fan
Keywords: mega-latticed structure, aluminum alloy, super-long span city domes, static properties, stability, load-displacement curves

Room: HIL E8 - WG 3+4 Technical Expert Group on Shell Structures for Energy Supply & Technical Expert Group on Masts and Towers

Moderator: **Sudarshan Krishnan**

252 An innovative hollow-cable-strut system for indoor cooling application
Shu Li, Xingfei Yuan, Zhendong Qiu and Akram Samy
Keywords: cable domes, thermal analysis, hydraulic analysis, structural bearing capacity, cooling simulation

479 Beyond Babel: Towering With Minimal Communication
Tsung-Wei Cheng, Kevin Harsono, Yuxi Liu, Ching-Yen Chen, **Shen-Guan Shih** and Oliver Tessmann
Keywords: SL Block, Parallel Assemblies, Attribute Grammar, Autonomous Constructions, Dry Stacking

479 Astrup Fearnley Museum: Structural Design and Detailing of the Stayed Masts
Sudarshan Krishnan
Keywords: stayed masts, museum, stability behavior, structural design, detailing

Room: HIL E9 - WG 22 Architectural Geometry

Moderator: **Cyril Douthe, Toby Mitchell, Eike Schling**

280 Interactive Design of C-shells Using Reduced Parametric Families
Quentin Becker, Seiichi Suzuki and Mark Pauly
Keywords: deployable gridshells, design exploration, computational design, physics-based simulation

340 Design of gridshells consisting of planar curves using Laguerre geometry
Kohei Kabaki, Kentaro Hayakawa, Makoto Ohsaki, Yoshiki Jikumaru and Yohei Yokosuka
Keywords: gridshell, Laguerre geometry, canal surface, form finding, cross-sectional optimization

220 Equilateral Constant Normal Curvature (ECNC) Gridshell
Haotian Man, Zongshuai Wan, Davide Pellisa, **Eike Schling**
Keywords: Equilateral Constant Normal Curvature, ECNC, Gridshell, Parametric design, Geometry, asymptotic curves, geodesic curves, elastic bending and torsion, curvature analysis, kit-of-part, repetitive structure

260 Non-developable surface structures using bilayer auxetic material and kerf bending joints
Kazuki Hayashi and Romain Mesnil
Keywords: Shell, Conformal mapping, Auxetic structure, Kerf bending, Digital Fabrication

365 Sequential generation method for hexagonal lattice shells with edge offset mesh
Ryo Watada and Makoto Ohsaki
Keywords: Hexagonal Lattice shell, Edge Offset mesh (EO mesh), Koebe mesh, Optimization

117 Free-form Surface Approximation Using Congruent Regular Triangles
Yuanpeng Liu, Ting-Uei Lee and Yi Min Xie
Keywords: architectural geometry, rationalisation, mesh topology, optimisation, facade design, free-form surface

244 Minimal surface based elastic gridshell design
Xinye Li, Mohammad Mansouri, and Ahmed Elshafei
Keywords: Architectural Geometry, Minimal Surfaces, Holomorphic Functions, Principal Curves, Asymptotic Curves, Differential Geometry, Architectural Fabrication

Monday

Slot 2: 16:00-17:30

Room: HIL E3 - WG 12 Timber and Bio-based Spatial Structures

Moderator: **Minjuan He**

166 Design to construction workflow of a robotic fabricated double-curved strained grid-shell structure
Mingzhe Wang, Kai Pang and Sihan Wang
Keywords: Reciprocal Structure, Small timber elements, Workflow, Design, Construction, Robotic fabrication

182 The Chebydesic pavilion: a path toward flattenable geodesic elastic gridshells
Charles Haskell, Aymeric Manté, Nicolas Montagne, Cyril Douthe and Olivier Baverel
Keywords: Elastic gridshell, Geodesics, Flattening, Isogeometric analysis, Nonlinear structural analysis

81 Integrative structural design methods for bamboo woven deployable structures: The BamX! Research Pavilion
Tzu-Ying Chen, Seiichi Suzuki, Marta Gil Pérez, Yanan Guo and Jan Knippers
Keywords: Deployable structures, Bamboo woven architecture, Computational design, Integrative design, Material characterisation, Mechanical testing, Non-standard material, Structural design

530 Curve-Fit, Free-Form Timber Structures through Curved-Folded Modules
Alan Eskildsen, Pinaki Mohanty, Caroline Leite Vieira, Simon Bechert, Axel Körner and Jan Knippers
Keywords: curved folding, bending-active, timber, flat-pack, transformative structures, deployable structure, finite element analysis, optimization, free-form, lightweight structures, reversibility

297 Pre-rational approach for bamboo construction from a Dini surface
Aly Abdelmagid, Zlata Tosic, Marta Orszt, Maximilian SchwallL, Martin Eichenauer, Egor Ivaniuk, Daniel Lordick, Olivier Baverel, Ahmed Elshafei
Keywords: Bamboo structures, Low-tech fabrication, Pre-rationalization, Traditional techniques, Design for assembly and disassembly, Falsework-free construction

499 Parametric design and digital fabrication of disassemblable elastic timber gridshells with principal curvature lines network and carpentry joints
Carlos Martínez-Criado, Antonio José Lara-Bocanegra, Antonio Roig, Francisco González-Quintial, Andrés Martín-Pastor and Almudena Majano-Majano
Keywords: Active bending, Carpentry joints, CNC machining, Computational design, Construction-aware design, Design for disassembly, Lightweight structure

Room: HIL E4 - WG 13 Computational Methods

Moderator: **Hazuki Hayashi**

96 Practical Applications of Constrained Form-Finding in Structural Design
Lennert Loos and Kenryo Takahashi
Keywords: Numerical Method, Form-finding, Optimisation, Geometry, Early Design Phase

407 Curvature-driven Optimization in Grid-shell design : An innovative Force density method application
Rina Kim, Jihyun Kim and Sung-Gul Hong
Keywords: Grid-shell, force density method, curvature-driven optimization, Willmore energy, Maxwell diagram

627 Form finding by shape optimization with implicit splines and vertex morphing
Kai-Uwe Bletzinger
Keywords: form finding, shape optimization, computational methods

94 Clustering-based periodic structural optimization with variable orientations of unit cells
Yunzhen He and Yi Min Xie
Keywords: Topology optimization, Periodic optimization, Bi-directional evolutionary structural optimization (BESO), Dynamic clustering, Oriented periodicity

164 Graphical and numerical method of form-finding for membrane structures
Kenryo Takahashi, Dongyuan Liu, Julian Lienhard
Keywords: graphic statics, form and force diagram, form finding, membrane structures, tensile structures, conceptual design, architectural geometry, numerical method

317 An Automated Triangular Mesh Partitioning Method for Surfaces Based on Multi-Objective Optimization
Zhengning Li, Xiaonong Guo and Jinhui Luo
Keywords: assembly path optimization, spatial structure, graph representation, greedy algorithm

Room: HIL E6 - WG 17 Historical Spatial Structures

Moderator: **Marisela Mendoza**

385 Restoration and repair of Félix Candela's most celebrated shell: 'Los Manantiales' Restaurant
Juan Ignacio del Cueto, Andres Lopez and Marisela Mendoza
Keywords: Felix Candela, Los Manantiales Restaurant Xochimilco, Concrete Shell, Restoration and repair, Restructuring works, Earthquake 2017

618 Ferrocement, an historical material to build shell and spatial structures
Erica Lenticchia, Francesco Tondolo, Amedeo Manuello and Rosario Ceravolo
Keywords: historical structures, Pier Luigi Nervi, ferrocement, corrosion

621 Knowledge path and analysis of the Binishell structures. The case study of villa La Cupola in Paradise Coast (Sardinia)
Giorgia Mellone, Diego Talledo, Luisa Berto and Sara Di Resta
Keywords: Binishell, Dome structures, Modular structures, Knowledge Path, Conservation, Safety evaluation

161 Prolonged life for the Ullevi stadium's cable suspended roof
Alexander Sehlström and Daniel Ekström
Keywords: cables, service life, stadium

313 Art as a strategy for the preservation of 20th Century concrete shell structures
Julia Mundo Hernández, Carola Santiago Azpiazu and Moisés Barrera Sánchez
Keywords: Hyperbolic paraboloid concrete shell, Building heritage, Umbrella-type concrete shell, Building preservation

373 Guillermo González Zuleta and the Emergence of Shell Construction in Colombia
Julian Palacio
Keywords: History of shell construction, Structural form in Latin America, Spatial structures in Colombia, Reinforced ceramic shells

500 Search for an Equilibrium in Multimodal Performance New Variations of Traditional Cap Ceilings
Emil Brechenmacher and Christoph Gengnagel
Keywords: Prussian Cap Ceiling, Building Physics, Norms and Standards, Sound Insulation, Acoustics, Vibration Requirements, Thermal Capacity, Circular Construction, Low Carbon, Masonry Vaults

541 Simplifying the construction concept of the elemented Zollinger roof
Alexander Stahr, Marius Zwigart, Vladimir Mandtler, Christian HEIDENREICH , André KILIAN and Katrin VÖGELE
Keywords: Prussian Cap Ceiling, Building Physics, Norms and Standards, Sound Insulation, Acoustics, Vibration Requirements, Thermal Capacity, Circular Construction, Low Carbon, Masonry Vaults

213 Rethinking truss beams and rigid structural frames of The Crystal Palace
Toshiaki Kimura, Hinata Okamoto, Yosuke Komiyama and Satoru Kimura
Keywords: The Crystal Palace, 3D CAD/CAM, FEM, Truss girder, rigid frame

Room: HIL E7 - WG 8 Metal Spatial Structures

Moderator: **Joseph Burns**

484 Structure and Transparency - Engineering the Shanghai Expo Cultural Park Greenhouses
Matthew Tam, Robert Vierlinger and Árpád Novák
Keywords: structures, engineering, slenderness, optimisation, cable, circle

258 Evolution of Design Integration with Digital Fabrication: Post-Covid Update
Joseph Burns
Keywords: Detailing and Construction, Building Information Modelling, Advanced Manufacturing, Design Integration, Sustainability

77 De-propping Analysis of İzmir Adnan Menderes Airport New Domestic Terminal Barrel Vault Roof with Structural Health Monitoring System
Ali Faik Ulusoy and İsmail Gürkan AkdoĞan
Keywords: Structural Health Monitoring, structural analysis and design, depropping, steel installation

366 Iona SkyDome, A Structural Steel Gridshell at the Upper Deck of a Cruise Ship
Kosmas Moupagitsoglou and Lorenzo Santelli
Keywords: dome, gridshell, glass, snap-through buckling, vibrations, structural optimization, FEA

346 Efficient strategy to increase natural frequencies in pods of the new Red Sea Airport
Borja Llorens, Josu Goñi, and Ruben Fernandez
Keywords: red sea airport, vibration modes, space frame shell

524 Structural design of folded strip forms with planar trusses
Ken Noda and Yoshiharu Kanebako
Keywords: Structural design, Folded strip structure,Truss beam, Wind tunnel test

441 Steel structure roof design of terminal T2 of Mianyang Nanjiao Airport
Xin'An Xiang, Yuan Feng Hengfei Zhang and Keliang Han
Keywords: space grid structure, numerical inverse hanging method, structural form-finding, pre-tensioned cable column

Room: HIL E8 - No Presentations
Moderator:

Room: HIL E9 - WG 22 Architectural Geometry
Moderator: **Cyril Douthe, Toby Mitchell, Eike Schling**

296	Democratizing the construction of multiple reciprocal frame structures using adaptive connectors	
	Shrey Gupta and Olga Popovic Larsen	*Keywords:* Reciprocal Frame Structures, Adaptive Connector, Non-standard Member, Rapid Construction, Buildability, Anticlastic Surface Structures, Fabrication, Swivel-Ring Coupler, Riveting System
345	Constructing Topological Interlocking Assemblies Based on an Aperiodic Monotile	
	Reymond Akpanya, Tom Goertzen, Yuanpeng Liu, Sascha Stüttgen, Daniel Robertz, Yi Min Xie and Alice C. Niemeyer	*Keywords:* Topological interlocking, 3D-printing, Computational form finding, Aperiodic monotile, Einstein problem, Hangai Prize applicant
42	The influence of module quantity on the curvature of 3D chain mail structures	
	Nabila Afif, Charlie Ranscombe and Jane Burry	*Keywords:* chain mail structure, interlocking assembly, modular construction, geometric design, curved structure
56	Informing Architecture with Generated 3D Solid Models	
	Dr Seda Zirek	*Keywords:* Material Synthesis, Machine Learning, Structural Design, Generative Models, 3D Solid Models
188	Euler Path Structures: design exploration with reconfigurable continuous, flexible material	
	Fereshteh Khojastehmehr, Moria D. Schwarz and **Günther H. Filz**	*Keywords:* Euler Path, graph theory, architecture, reuse, circular design, sustainability, Spatial structures, elastic gridshell
230	Aggregated Structure and Forming of Controlled Star-shaped Particles	
	Hung Wen Lu and June Hao Hou	*Keywords:* granular packing methods, star-shaped particle geometry, aggregate structure, granular assemblies
131	An innovative modular block system for rammed earth construction	
	Ahmed Abdelaal, Jiaming Ma and Yi Min Xie	*Keywords:* Rammed earth, modular construction, free form, advanced fabrication, sustainability

Tuesday

Slot 3: 9:30-11:00

Room: HIL E3 - WG 21 Advanced Manufacturing and Materials

Moderator: **Arno Pronk, John Orr**

48 New Reinforcement Approach for Freeform Concrete Components through Carbon Fiber 3D Printing
Fatemeh Salehi Amiri, Abtin Baghdadi, Hyunchul Kwon
Keywords: Carbon fiber reinforcement, 3D printing, Computerized materials, Exoskeleton structures, Freeform, Concrete components

49 Monitoring the VARTM production process of a novel flax fiber-reinforced composite footbridge with FBG sensors
Marco Manconi and Spg Faas Moonen
Keywords: fiber-reinforced polymers, FBG sensors, VARTM, footbridges, natural fibers, flax-fibers, bio-composites

540 Applications of optimal reinforcement layouts for concrete slabs via digital fabrication methods
Leanna Bradbury, Andrew Liew and Matthew Gilbert
Keywords: Optimization, Grillage, Laser-cut, Reinforcement, Digital fabrication, Concrete, Flat slab

562 Structural Evaluation of Shotcrete 3D Printing and Robotic Fiber Winding for Thin Shell Elements
Philipp Rennen, Stefan Gantner, Tom Rothe, Bilal Baz, Serge Nana, Helene Lombois-Burger, Christian Hühne and Norman Hack
Keywords: Additive Manufacturing in Construction, Shotcrete 3D Printing, Robotic Fiber Winding, Green-State Post-Processing, CNC Concrete Milling, Textile-Reinforced Concrete, Flexural Strength, Digital Fabrication

343 Overview of Injection Liquid Printing with Dredged-Based Material for Concrete Formwork
Tzu-Hsien Lo and Bosheng Liu
Keywords: Rapid Liquid Printing, Dredged-Based Material, Reusable Material, 3D Printed Formwork, Reusable Concrete Formwork

1 Application of Water Jet Cutting and Optimization Problems in the Development of a New Concrete Construction System
Abtin Baghdadi, **Lukas Ledderose** and Harald Kloft
Keywords: Concrete, Water-Jet, Building, Dry connections, Optimization Algorithm, Precast

419 Robotic 3D Printing on inclined surfaces using adaptive formwork principles for prefabricated curve-like structures
Christos Georgiou and Odysseas Kontovourkis
Keywords: Inclined surfaces, Prefabrication, 3D Printing, Construction scale, Cement-based materials

Room: HIL E4 - WG 13 Computational Methods

Moderator: **Carlos Lazaro**

21 Modelling of Prestress Losses in 3D Tendon Layout Optimization Using Strain Energy Minimization
Hanna Domnick and Juan Pablo Osman-Letelier
Keywords: prestressed concrete, prestress force, prestress losses, conceptual design, structural design, tendon layout optimization

25 A grammar-based framework for strut-and-tie modelling of reinforced concrete structures
Karin Yu, Michael Kraus, Eleni Chatzi and Walter Kaufmann
Keywords: reinforced concrete, membrane structures, strut-and-tie models, truss structures, shape grammar, generative design

575 Designing strut-and-tie networks by graph theory and local Airy polyhedra
Jihyun Kim, Rina Kim and Sung-Gul Hong
Keywords: strut-tie model, graphic statics, Airy stress function, load path design, graph theory, rigidity theory, Maxwell-Cremona corrrespondence

222 Structural Analysis Using the Redundancy Matrix and Graph Theory
David Forster, William F. Baker and Manfred Bischoff
Keywords: Structural Redundancy, Redundancy Matrix, Graph Theory, Structural Assessment

254 Investigation on an Analytical Approach for Tendon Layout Optimization Using Strain Energy Minimization
Juan Pablo Osman-Letelier, Johanna Hintringer and Minu Lee
Keywords: computational analysis, symmetry, group theory, vector-space decomposition, idempotent, symmetry subspace, symmetry-adapted variable

390 On the decomposition of degenerate subspaces of symmetric structural configurations
Alphose Zingoni and Chisanga Kaluba
Keywords: computational analysis, symmetry, group theory, vector-space decomposition, idempotent, symmetry subspace, symmetry-adapted variable

454 Spanning Trees and Half-Edge Mesh construction in the complete Graphic Statics method for frames
Georgios-Spyridon Athanasopoulos, Yankun Yang, Russell Feathers and Allan McRobie
Keywords: Graphic Statics, Maxwell, Rankine, Reciprocal diagrams, Form and force diagram, Polyhedral geometry, Higher-dimensional polyhedra, Graph Theory, Spanning Tree, Minimum Spanning Tree, Half-Edge Mesh, Frames, Moment-Resisting

487 Enhancing Spatial Truss Designs by Integrating Metaheuristic Optimization via Visual Programming in BIM-based Projects
Feyzullah Yavan, Reza Maalek and Shahrokh Maalek
Keywords: Structural Optimization, AI in Design, Generative Modeling, Parametric Design, Visual Programming

Room: HIL E6 - WG 5 Continuous Shells

Moderator: **Stefano Gabriele**

274 The Future of Lightweight Structures in Research and Practice - The Stuttgart Model
Lucio Blandini
Keywords: shell structures, digital design and manufacturing, sustainable built environment

376 Architectural precast concrete shell
José Luis Encarnación Miranda, Juan Gerardo Oliva Salinas, Ronan Bolaños Linares, Mauricio Enrique Reyes Castillo, Carlos Arce León and Dulce Rosario Ponce Patrón
Keywords: double-curved, architectural precast, concrete shell, glass fiber, computational tools, digital manufacturing

177 Plotting eccentricity lines on continuous shells: discussion and examples
Arianna Venettoni, Stefano Gabriele, Ginevra Salerno and Valerio Varano
Keywords: Streamlines, Generalized eccentricity, Shell structure, R-Funicularity

14 Form Finding of Membrane Shells via Geometric Stiffness Methods: Overview and Characterization of Well-Posed Problems
Andres Felipe Guerra Riaño, István Sajtos and Péter L Várkonyi
Keywords: Membranes, Shells, Spatial structures, Well-posedness, Form finding

46 Design of Concrete Plates and Shells: A Solved Problem?
Vera Balmer, Karel Thoma and Walter Kaufmann
Keywords: Concrete plates and shells, Reinforcement design, Sandwich model, Layered shell element, Experimental testing

Room: HIL E7 - WG 6 Tension and Membrane Structures

Moderator: **Marijke Mollaert Ken'ichi Kawaguchi**

39 Exploring the potential of adaptive Monte Carlo simulation with importance sampling to predict the structural reliability of highly nonlinear tension structures
Peter Gosling
Keywords: Structural reliability, Adaptive Monte Carlo, Importance sampling, Analysis for design, Eurocode

175 Investigations into load history dependencies in the stress-strain behaviour of PVC-coated polyester fabric
Jörg Uhlemann and Natalie Stranghoener
Keywords: Textile membranes, stress-strain behaviour, stiffness, load history, cyclic test

341 Wind load analysis of a series of arch-supported membrane structures
Krisztian Hincz, Sherly Joanna Pool-Blanco, Richárd Joao Rosa, Márton Koren, and Márton Balczó
Keywords: membrane structure, wind load, wind tunnel experiment, pressure coefficient, Computational Fluid Dynamics

607 Plastic limit load solution for plate under combined tension and bending with any load ratio considering plastic development depth
Tong Sun and Yuanqing Wang
Keywords: plastic limit load, plastic development depth, load ratio, combined loading, finite element analyses

168 Study on the creep performance of steel wire ropes
Manyu Deng and Xingfei Yuan
Keywords: elastic modulus, cable-strut structure, long-term, constitutive equation, steel wire rope

439 Shifting towards eco-responsible construction: bio-based and biodegradable polymers as substitutes for synthetic membranes
Maria Naïssi, Dana Saez, Max KRUSZEWSKI, Steliyana YANCHEVA and Martin Trautz
Keywords: bio-polymers, membrane structures, tensile strength, gelatine, bio-based, bio-degradable

101 Rigid Model Design and Wind Tunnel Tests of Large Span Tower-Cable Network System
Mingzhe Ma, Chao Yang and Yaozhi Luo
Keywords: Ultra-High Tension Tower, extensive slack line network, wind tunnel text

379 Analyzing the impact of wind and snow loads on long-span tensile membrane structures: investigating structural response and performance
Ruikai Wang, Xiaoying Sun and Jialin Zou
Keywords: long-span structure, wind and snow loads, response

Room: HIL E8 - WG 15 Structural Morphology

Moderator: **Niels De Temmerman**

This session will meet outside - behind the HIB building - to review the structural pavilion prototypes that have been installed. All "authors" of the structures will give a brief presentation of their pavilion, followed by discussion

Room: HIL E9 – WG 12 Timber and Bio-based Spatial Structures

Moderator: **Pierluigi D'Acunto**

172	Formulation of elastic stress in the fiber transverse direction of full-culm bamboo subjected to bending **Takuo Nagai**	*Keywords:* Full-culm bamboo, Bending failure, Brazier effect, Anisotropy
193	An Accessible Framework for Optimizing the Structural Performance of Wood-based Building Components **Johannes Belz** and Benjamin Kromoser	*Keywords:* topology optimization, shape optimization, structural optimization, genetic algorithm, finite element analysis, timber, engineered wood, structural element
245	Timber Gridshells: Challenges and strategies in fabrication and assembly **Sebastian Hoyer**, Pierluigi D'Acunto and Eike Schling	*Keywords:* timber gridshell, free-form structures, timber construction, asymptotic paths, geodesic paths, construction-aware-design, lightweight structures, parametric design, active bending, architectural geometry
24	Biaxial spanning flat solid wood slab Asko Fromm, **Peer Röder**, Melf Sutter and Florent Keller	*Keywords:* Timber construction, computational design, digital fabrication, optimization
153	Structural design challenges of bio-based composites and digital fabrication towards sustainable building systems **Marta Gil Pérez**	*Keywords:* structural design, digital fabrication, digital-physical workflow, multi-scale simulation, coreless filament winding (CFW), bio-based composite materials, sustainable structures, circular design
598	Geometry, Material and structural exploration for curved cross-laminated timber structures Juan Sebastian Zambrano-Jaramillo, Erica Fischer and **Dylan Wood**	*Keywords:* Surface Structures, Wood, Timber, Cross Laminated Timber, FEM, Material Efficiency
600	Timber Structures for Circularity: Reinterpreting Lessons from the Past **Nancy Cheng**, Rafael Passarelli and Mariapaola Riggio	*Keywords:* Circular economy, reclaimed wood, small-dimension wooden elements, wood-to-wood connections

Room: HIL E3 - WG 12 Timber and Bio-based Spatial Structures

Moderator: **Matthias Beckh**

130 Limitations in the use of reclaimed wood on spatial structures in a carpentry workshop; a field study
Wolfgang Schwarzmann
Keywords: reclaimed wood, CNC-machine, wood-only construction, field research, 1:1 case study, digital fabrication, circular construction, timber construction

545 Simple top-down parametric method for designing timber gridshells using geodesic networks controlled along the boundary of translation surfaces
Rodrigo Shiordia Lopez and Juan Gerardo Oliva Salinas
Keywords: timber gridshells, parametric design of timber gridshells, geodesic curve networks, elastic timber gridshell modeling

589 Performance-Based Design of a Bending Active Hardwood Glulam Beam-String: a Form-Finding Paradox.
João Tavares Pini and Hélio Olga
Keywords: Karamba, Beaver, Open source, Rhino, Grasshopper, Form-Finnding, Spatial Structures, Eurocode 5, Timber, Hardwood, Inverted arch truss, Fish belly truss, Imposed Curvature, Curvature, Optimization, Grid Shell, Finit Element Analysis

198 Enabling the circular use of Cross-Laminated Timber by upcycling production waste upcycling production waste
Nathan Dupas and Markus Hudert
Keywords: Cross-laminated timber (CLT), Production Waste, Reuse, Circular Economy, Computational Method, Combinatorial design, Stock-constraint Design Tool

250 Enabling the circular use of Cross-Laminated Timber by upcycling production waste upcycling production waste
Marc Serra Ureta and Alex Sola de Los Santos
Keywords: gridshell, lamella gridshell, zollinger system, rotational stiffness, optimization, joints, timber, digital fabrication, parametric design

129 Digital-Parametric Planning Processes For A Resource-Saving Redensification In Timber Construction
Jovanka Kuzmanovska, Sebastian Bartsch and Matthias Beckh
Keywords: Timber panel construction, Spatial configuration, Parameterized planning, Free-span load-bearing systems, Vertical densification

398 Sustainable material using bamboo-based substrate mycelium composite
Jui-Ho Tseng, Huei-Ying Huang and **Bosheng Liu**
Keywords: Biodegradable materials, Bamboo Fiber, Mycelium Bamboo Substrates

416 Investigating the Reuse of Formwork Wood: Assessing the Structural Qualities
Gabrielle Nicolas, Didier Snoeck and Lars De Laet
Keywords: Formwork Wood, Circularity, Waste, Structural Design

Room: HIL E4 - WG 15 Structural Morphology

Moderator: **Niels De Temmerman**

45 Exploring and optimizing innovative structures in virtual reality
Zhi Li, Ting-Uei Lee and Yi Min Xie
Keywords: Structural design, Virtual reality, Topology optimisation, Subjective preferences, Hangai Prize applicant

329 Exploring Innovative Spatial Structures through TopologicalvOptimization and Snow Material Integration in Cold Climate Construction
Ding Wen Bao, Xin Yan and Yi Min Xie
Keywords: Snow Structure, Topology Optimisation, Bi-directional Evolutionary Structural Optimization (BESO), Natural Materials, Innovative Pavilion, Form-finding

109 Facilitation or inhibition: The influence of generative artificial intelligence on design reasoning for modular structures
Miingli Sun, Kostas Terzidis and Jianhao Chen
Keywords: Modular Structure with Repeating Units, Design Reasoning, Design Cognition, Collaborative Design

143 Augmented Morphological Designs Enabled Through Network-Based Genetic Algorithms
Paul Kalnitz and Aaron Sprecher
Keywords: evolution, evo-devo, architectural morphology, hierarchical modularity, machine learning, neural networks, complexity

194 Characterizing spatial structures with optimal strength or stiffness
Helen Fairclough
Keywords: Optimization, Ground Structure Method, Truss Topology Optimization, Compliance-based Optimization, Strength-based Optimization

144 On graphical methods applied to cantilevering forms
Giancarlo Torpiano and Allan McRobie
Keywords: graphic statics, form-finding, Maxwell, cantilevering structures, computational design, shell design

617 Free-form Grid Structure Form Finding based on Machine Learning and Multi-objective Optimisation
Yiping Meng and **Yiming Sun**
Keywords: Free-form structure, Multi-objective optimisation, Genetic Algorithm, Structural Morphology, NURBS

522 Computational Form-finding of Structures through Constraint Projections
Jonas Warmuth, Pierluigi D'Acunto and Corentin Fivet
Keywords: form-finding, geometry optimization, conceptual design, numerical method, computational design, interactive design

554 Legendre transforms for graphic statics with moments
Allan McRobie, Marina Konstantatou and William Baker
Keywords: Graphic statics, Legendre transforms, Bending moments, Reciprocal figures, Maxwell reciprocals, Rankine reciprocals

Room: HIL E6: WG 5 Continuous Shells
Moderator: **Sigrid Adriaenssen**

51 Design, structural optimization and fabrication of concrete shells through fibre-reinforced 3d printing
Victor De Bono, Nicolas Ducoulombier, Romain Mesnil and Jean-François Caron
Keywords: Additive manufacturing, Reinforcement, 3D printing, Structural optimization, Shell

266 Design-to-production of a precast post-tensioned concrete shell structure using the CASTonCAST system
Lluis Enrique Monzo, Alessandro Dell'Endice, Tom Van Mele, Philippe Block and Joseph Schwartz
Keywords: Shell structures, Precast construction, Post-tensioning, Graphic statics, Fabrication techniques, Research by design

599 The "Lookout" sculpture: Design and construction of freeform reinforced brick vaulting
Lara Davis, Rebecca Buntrock, Martin Puryear, Rob Horton, John Ochsendorf
Keywords: freeform vault construction, Nubian vaulting, double curvature, reinforced masonry, brick shell, minimal formwork, shear ties, natural cement

113 3D Scanning and structural analysis of Heinz Isler's shell for swimming pools
Peter Eigenraam, Qingpeng Li , John Chilton, **Andrew Borgart**
Keywords: Isler, 3D scanning, point cloud, reverse engineering, surface fitting, shell assessment, Heimberg pool

418 Integrating Agricultural Waste Product in Building Material: Biochar Mixed with Dredged Material Based Tile Vault
Bosheng Liu, Chyi-How Lay, Chao-Chen Hsu, Kuan-Chia Chu, Ting-Wei Hsu, Ching-Yu Tseng, and Chien-Chun Su
Keywords: structural design, thin-tile vaults masonry, earthquake design, compressed-earth blocks, biochar tile, dredged material tile

241 The Overlook – A shell structure with multi-element interfaces
Gabriel Rihaczek, Alessandra Roani, Isabelle McKinnon, Ahmed Bestam, Germain Mukendi, Joseph Tessier, Thomas Lücking
Keywords: Computational design, Structural design, Shell structure, Reinforced concrete, Vaults

301 Structural form-finding, design and analysis of a freeform concrete shell for a gas station canopy
Qingpeng Li, Qijian Wu, YaoYe, Zai Wang
Keywords: freeform shell, form-finding, design, analysis, boundary conditions

Room: HIL E7 – WG8 Metal Spatial Structures
Moderator: **Shaojun Zhu**

95 The latest enhancement to Guides of Metal Roof Spatial Structures
Toru Takeuchi, Su-Duo Xue, Shiro Kato, Jinzhi Wu, Yuki Terazawa and **Ben Sitler**
Keywords: Metal Spatial Structures, Stability, Buckling, Dynamic, Seismic Response

139 Investigation into the progressive collapse of double-layer space structures with double-layer vertical walls using the alternative path method
Karim Abedi**, Fariba Hassannezhad** and Mohammad Kheirollahi
Keywords: Progressive collapse, Alternate path method, Double-layer space structures

146 Experimental and theoretical study on reticulated shell structure composed of plate members
Hui-Bin Ge
Keywords: Reticulated shell structure, Stability behavior, Experiment, Numerical analysis

288 Probability Model of Non-linear Buckling Capacity of Single-Layer Reticulated Shells Using Constrained Stochastic Imperfection Modal Method
Chenyu Wu, Shouchao Jiang and Shaojun Zhu
Keywords: single-layer reticulated shells, non-linear buckling capacity, probability model, constrained stochastic imperfection modal method

395 Effect of Accordion Force Limiting Device on Double Layer Barrel Vaults Seismic Behaviour
Maryam Poursharifi, Yashar Yasrebi Nia and Zahra Poursharifi
Keywords: Accordion force limiting device, Barrel vaults, Space structure, Seismic behavior

404 Stability analysis of double layer grids equipped with accordion force limiting device
Zahra Poursharifi and Saeid Poursharifi
Keywords: Accordion Force Limiting Device, Double layer Grid, Stability analysis, Progressive Collapse

147 Responses of single-layer spherical reticulated shell with initial geometrical defects under multi-directional ground motions
Yahong Luo, **Jun Gong**, Hongtao Zuo and Yongbo Shao
Keywords: single-layer spherical reticulated shells, initial geometrical defects, incident directionality, numerical calculation, nonlinear time analysis, structural responses

Room: HIL E8 – SS13nm Numerical methods for geometry, form-finding and optimization of lightweight structures

Moderator: **Carlos Lazaro + Hazuki Hayashi**

19	Free-Form Coupled Funicular Curves **Ágoston P. Szesztay** and Péter L. Várkonyi	*Keywords:* free-form, funicular, design, bridge, post-tension
348	Continuum optimization of 3D printed self-supported shell: hybrid strategy for crafting ribbed system Mohamad Fouad Hanifa**, Bruno Figueiredo,** Deena El-Mahdy, Paulo Mendoça and Daniel V Oliveira	*Keywords:* Structural optimization, form finding, additive manufacturing, topological optimization, supporting systems, self-supporting structure, rib topology
223	Isogeometric form-finding of membrane shells based on single-objective optimized Airy stress function **Claudia Chianese**, Francesco Marmo and Luciano Rosati	*Keywords:* Form finding, Isogeometric analysis, Membrane shells, Pucher's model, Single-objective optimization
308	Discrete thickness optimization for free-form shell structures based on multi-material topology optimization **Yu Li**, Xinjie Zhou, Philip F. Yuan	*Keywords:* topology optimization, multi-material topology optimization, shell design, thickness optimization
304	Integrating Shape and Topology Optimization: A Multi-Stage Design Approach for Shell Structures **Saaranya Kumar Dasari**, Patrizia Trovalusci, Nicholas Fantuzzi and Marco Pingaro	*Keywords:* Sustainable Design, Dynamic Relaxation, Topology Optimization, Global Warming Potential, Buildability
427	Layout optimization of vaults: from benchmark to practical solutions **Linwei He**, Helen Fairclough, Yuanpeng Liu, Matthew Gilbert and Catherine Rankine	*Keywords:* vault, form-finding, layout optimization, minimum material design
360	Numerical analysis with experimental verification of a multi-layer sheet-based funicular glass bridge **Damon Bolhassani**. Delaram Hassanlou, Fahimeh Yavartanoo, Masoud Akbarzadeh, Yao Lu, Joseph R. Yost, Jorge Huisa Chacon, Jens Schneider and Philipp Chhadeh	*Keywords:* Numerical Analysis, Finite Element Method, Funicular Structures, Sheet-Based Structure, Glass Bridge

Room: HIL E9 – WG 22 Architectural Geometry

Moderator: **Cyril Douthe, Toby Mitchell, Eike Schling**

47	The geometry of the flow of forces and moments across a shell **Chris J K Williams** and Emil Adiels	*Keywords:* Shells, Formfinding, Graphic statics, Airy stress function, Beltrami stress functions, Günther stress functions, Redundant forces and moments, Membrane theory, Pucher's equation
272	The design of gridshells with torsion free layout and planar quad made simple **Cyril Douthe,** Romain Mesnil and Olivier Baverel	*Keywords:* Paralell mesh, gridshell, torsion free node, structural design
124	Nervi Puzzle: a topologically reconfigurable modular ribbed floor **Robin Oval**	*Keywords:* structural design, computational design, generative design, structural optimization, grammar, topology, patterns, modularity, reconfigurability, circular economy
165	Solving bilinear equations to align conjugate curvature and stress directions in NURBS-based form-finding of shells **Masaaki Miki** and Toby Mitchell	*Keywords:* shell, stress function, variable projection method, bilinear partial differential equation, form-finding method
4	Transformative Impact of the New Hartford Healthcare Amphitheater on the Revitalization of Bridgeport, Connecticut **Andres Villasenor** and Javier Rattia	*Keywords:* Rehabilitation, Amphitheater, Sustainable
561	Integrated Design and Architectural Geometry for the Southern Dunes Canopy **Marina Konstantatou**, Dmitris Themelis, Maximilian Zielinski and Irene Gallou	*Keywords:* Architectural geometry, Integrated design, Canopies, Sun analysis, Tensile structures

Room: HIL E3 – WG 12 Timber and Bio-based Spatial Structures

Moderator: **Petras Vestartas**

392 Heuristic Fabrication: An Interactive Robotic Building System for Enhancing Human Participation in Timber Structures
Teruyoshi Kaneko, Arastoo Khajehee and Yasushi Ikeda
Keywords: Heuristic Design, Interactive Fabrication, Human-Robot Interaction, Modular Assembly, Human-in-the-Loop

578 Experimental Investigation for the Quantitative Assessment of Ungraded Timber in Floor Trusses
Salvatore Dario Marino, Harry Mills, Antiopi Koronaki, Darshil Shah and Michael Ramage
Keywords: material efficiency, robotic timber, local resources

604 Digital design and fabrication of adaptive metal nodes for timber space frame structures
Lukas Kirschnick, Prof. Dr. Jan Willmann and Prof. Dr. Jürgen Ruth
Keywords: space-frame structures from round timber, digital fabrication, universal metal nodes, Lost-foam casting, recycling leftover timber

461 Timber groin vault floor system for low-embodied carbon buildings
Shane Hossell, Will Hawkins, Antony Darby and Tim Ibell
Keywords: Timber, Groin vaults, Embodied carbon, Sustainable construction, Genetic algorithm, Optimisation

493 Interactive Mixed Reality Workflow for Ad-Hoc Gridshell Assembly
Nicholas Bruscia, **John Archilla**, and Antonio Vargas
Keywords: Mixed Reality, Fabrication, Timber Gridshells, Material Driven Workflow, Computational Design

510 Timber-Dowel Reciprocal Lattice System: Design Computation to Assembly, Case Study on Tetrahedral-Octahedral Voxelization
Sina Mostafavi, Tahmures Ghiyasi, Edgar Montejano Hernandez and Cole Howell
Keywords: Timber-Dowel Structures, Reciprocal Lattice Structures, Robotic Wood Construction, AR-Assembly, Resource-Driven Design

536 Symphony of Tradition and Technology: Integrating Traditional Woodworking Techniques with Biomimicry and Digital Fabrication
Matheus Rudo Oliveira and **Ludmila Andrade**
Keywords: Traditional Woodworking, Biomimetic Design, Digital Fabrication, Structural Efficiency, Sustainable Architecture

Room: HIL E4 – WG 15 Structural Morphology

Moderator: **Masoud Akbarzadeh**

311 Maximizing Number of States of Self-Stress in Spanning Grid-Shells
Arek Mazurek and William Baker
Keywords: States of self-stress, Grid-shells, Funicular, Airy stress function

73 Development and assessment of a spherical cap timber gridshell with compound beam sections
David Andersson Largueche and Riccardo La Magna
Keywords: timber construction, elastic bending, architectural geometry, numerical simulation

53 The structural behaviour of masonry bridges designed as hydrostatic shells
Emil Adiels, Mats, Ander, Fredrik Boman, Jacob Forsberg, Emil Svedjer, Erik Wigh and Chris Williams
Keywords: masonry bridge, membrane theory, differential geometry, hydrostatic shell, form finding

332 Generative Design Methodology Using Non-uniform Mesh Subdivision Based on Internal Force
Ziying Shi and Hang Dai
Keywords: Mesh subdivision, Heterogeneous grid shells, Structural morphology, Parametric design, Inner force images, Inside-out

551 How periodic surfaces bend without stretching
Hussein Nassar and Andrew Weber
Keywords: isometric deformation, bending, periodic shell, surface of translation, origami tessellation, Poisson's ratio, homogenization

112 Two units for the design of modular geodesic gridshells
Davide Pellecchia, Francesco Marmo and Luciano Rosati
Keywords: Geodesic gridshells, Modular units, Form-Mobility relationship

279 Structural Form-finding Integrating Vector-Based Graphic Statics and Non-Linear Force Density Method
Yuchi Shen, **Yinan Xiao**, Feifan He and Pierluigi D'Acunto
Keywords: Form-finding, Vector-based Graphic Statics, Nonlinear Force Density Method, Structural Optimization, Form Diagram, Force Diagram

555 Homology of Moment Frames
Zoe Cooperband, Allan McRobie, Cameron Millar and Bernd Schulze
Keywords: Moment frames, Homology, Algebraic topology, Static-kinematic duality, Maxwell-Calladine count, Bending moments, Shear forces, Kinematics

Room: HIL E6 – SS 5 Continuous Shells: New perspectives in research and construction (WG5)

Moderator: **Marisela Mendoza**

199 Structural behaviour of concrete shells using brittle reinforcement materials: a case study on stay-in-place flexible formworks with integrated high-strength textiles
Minu Lee
Keywords: formworks, textile reinforcement, digital fabrication, concrete shells, KnitCrete, ductility, non-linear modelling

251 Reconsidering the historical cap ceiling: Layerwise form-finding of self-supporting vaulted structures for in situ 3D printing
Frederic Chovghi, David Richter, Kathrin Dörfler and Pierluigi D'Acunto
Keywords: Historical cap ceiling, Vault structures, Self-supporting structures, Form-finding, Graphic statics, Additive manufacturing, 3D printing of cementitious mortar, In-situ fabrication

414 Concrete domes supported by external tendons: a novel concept for sustainable and efficient construction of concrete floor slabs
David López López, Rebecca Ammann, Carlos Lázaro, Walter Kaufmann and Jaime Mata-Falcón
Keywords: sustainable structures, continuous shells, digital fabrication, optimisation

440 Structural design and construction of a self-shaping single curved timber structure HygroShell
Kenryo Takahashi, Laura Kiesewetter, Axel Körner, Dylan Wood, Jan Knippers and Achim Menges
Keywords: Self-shaping wood, timber structures, shell structures, structural typology, construction method, digital fabrication

403 Bending-active molds for pre-fabricated concrete shells
Felicia Wagiri, Shen-Guan Shih, Yu-Chuan Kao, Tsung-Wei Cheng and Mu-Kuan Lu
Keywords: Bending-active structures, Prefabricated concrete shells, Fabric formwork, Geodesic grids

176 Brick Warp System – A Morpho-Static Paradigm
A. Basto Dioo and António Morais
Keywords: Double curvature, Form-finding, Structural morphogenesis, Digital tools

Room: HIL E7 – WG 8 Metal Spatial Structures

Moderator: **Alex Seiter**

532 Determination of stiffness requirements and design of appropriate small-scale stiffener layouts for robust lightweight metal shells
Alex Seiter and Martin Trautz
Keywords: Lightweight Structures, Structural Otpimization, Stability, Buckling, Metal Shells, Metal Forming

350 Structural and constructive resolution of eccentric structural wire model for West Gate tunnel Melbourne.
Josu Goñi, Iker Borde, Paula Usun and Peru San Miguel
Keywords: eccentric, wiremodel, west gate tunnel

559 Experimental study on wind uplift resistance of metal roofing system for large-span structure
Tianxiong Zhang, Yuanqing Wang, Jingfeng Wang, Wan Yi, Tingyi Li and Qunshan Zhang
Keywords: metal roofing system, wind uplift resistance, water tightness, full-scale model test, failure mode

149 Load-bearing test of a hybrid steel-concrete joint for discrete reticulated timber shell structures with six linear members
Žiga Unuk
Keywords: joint, discrete reticulated shell structures, timber, glued-in rods, concrete, steel, load test

307 Failure mechanism and design strength of spatial loaded high-strength welded hollow spherical joint
Chen Qiu, **Jihui Xing**, Lina Cheng, Na Yang and Ying Huang
Keywords: Welded hollow spherical joint, high-strength steel, spatial load, experiment, numerical simulation, failure mechanism, design formula

303 Engineering applications and research progress on mechanical properties of cast aluminium alloy for spatial structures
Huan Lu, Yuanqing Wang, Xinhang Zhi, Beibei Li and Shuai Mo
Keywords: cast aluminium alloy, engineering application, mechanical properties, research progress

259 Research on Mechanical Properties of Hot-dip galvanized Large Hexagonal Head High Strength Bolt
Liu Dong, Yu Xianglin, Zhao Shihua, Shi Yongjiu, Wen JiangTaoa, Zhang Shuanga, Shi Jun
Keywords: Mechanical property, Hot-dip galvanized bolt, Stress-strain curve

437 A Novel Shape Optimization Framework for Cast Steel Tubular Joints
Xiaonong Guo and Gen Li
Keywords: Shape optimization, Cast steel joint, Tubular joint, Subdivision surface

399 Load-bearing capacity of welded hollow sphere joints with trapezoidal ribs under combined axial compression and bending moment
Tingting Shu and Xian Xu
Keywords: Welded hollow sphere, External rib, Eccentric comprehension, Finite element model, Static response

Room: HIL E8 – SS13nm Numerical methods for geometry, form-finding and optimization of lightweight structures

Moderator: Harald Kloft

36	Dynamic Relaxation modeling of beam structures with a non-unit quaternion formulation Axel Larsson and **Sigrid Adriaenssens**	*Keywords:* dynamic relaxation, elastic rod networks, beam modeling, quaternions, automatic differentiation, form finding, co-rotational
41	Coupling form-finding methods for efficient structural shape optimization via gradient descent **Rafael Pastrana** and Sigrid Adriaenssens	*Keywords:* Form-finding, Optimization, Automatic differentiation, Differentiable programming, Structural design
320	Innovative form-finding method and modeling platform for cable dome design **Yan Zhou**, Migzhe Ma and Yaozhi Luo	*Keywords:* Cabel dome, Form-Finding, Modeling Platform, Dog-Leg method
3	Form Finding and Analyzing of Shells by Polynomial Equations and Artificial Neural Network **Abtin Baghdadi**, Lukas Ledderose and Harald Kloft	*Keywords:* Shell, Form Finding, Optimization, Artificial Neural Network, Share as Force, Polynomial Functions
269	Enhancing Non-linear Force Density Method through Combinatorial Equilibrium Modelling for form-finding spatial structures **Feifan He**, Yinan Xiao, Yuchi Shen, Hastia Asadi and Pierluigi D'Acunto	*Keywords:* Form-finding, Non-linear force density method, Combinatorial Equilibrium Modelling, initial force density set, constraint-based structural optimization
315	Isogeometric smoothed finite element analysis: Numerical investigations on applying essential boundary conditions Malik Qdeimat, **Markus Klassen**, Martin Trautz and Sven Klinkel	*Keywords:* Isogeometric Analysis, Finite Element Method, Smoothed Finite Element Method, Strain smoothing technique, Isogeometric Smoothed Finite Element Method
611	Form finding of spoke wheel systems with Airy stress polyhedra **Hiroki Tamai**	*Keywords:* spoke wheel system, form finding, graphic statics, dual Airy stress polyhedra

Room: HIL E9 – WG22 Architectural Geometry

Moderator: Martin Trautz

464	From Distortions to Design: Self-Morphing Frustrated Composites at Architectural Scale **Gal Kapon** and Arielle Blonder	*Keywords:* Self-morphing, geometric frustration, FRP, mouldless fabrication, digital fabrication
518	Improved Multibody Rope Approach for Free-Form Gridshells Shape and Construction **Amedeo Manuello Bertetto**, Jonathan Melchiorre and Giuseppe Carlo Marano	*Keywords:* Form-finding, Gridshells, Free-form, Architectural engineering, Construction process
572	A Framework for Structural Design of Topological Interlocking Flat Vaults **Elena Shilova**, Nicolo Bencini	*Keywords:* parametric structural design, topological interlocking, modular construction, historical construction, sustainable design
305	Designing an ideal deformation behavior of a bending-active gridshell based on rotating quadrilaterals **Yusuke Sakai**	*Keywords:* bending-active gridshell, form-finding, grid pattern design, compliant mechanism, rotating quadrilateral, mode separation, negative Poisson's ratio, eigenvalue analysis, large-deformation analysis
565	An automated topology optimization framework for material minimization in concrete building structures **Simone Peter** and Caitlin Mueller	*Keywords:* building-scale optimization, embodied carbon, structural optimization, topology optimization, automatic differentiation, gradient-based optimization algorithm, method of moving asymptotes
91	The effect of geometric tiling parameters on the stiffness of a rotational kirigami system **Isabel M. de Oliveira**, Emily Baker and Sigrid Adriaenssens	*Keywords:* kirigami, space frame, finite element method, parametric design
10	Stiffness-Scaled Models for Asymptotic Gridhshells: Designing and Prototyping **Judyta Cichocka** and Szymon Loj	*Keywords:* asymptotic gridshell, timber structures, site-sprung construction, structural optimization, multi-objective optimization, performance-driven design, computational design
356	Performance of sewing timber joints applied to an origami timber pavilion: design and analysis. **Mauricio Díaz** and Diksha Garg	*Keywords:* Timber sewn joints, origami geometry, lightweight structure, form finding, kevlar thread
135	Fornix: the circular platform-frame **Attilio Pizzigoni** and Valentina Beatini	*Keywords:* ashlar beams, interlocking-blocks, selfsubtained-structure, structural compressed elements, platformframe

Room: HIL E3 - WG 21 Advanced Manufacturing and Materials

Moderator: **Arno Pronk, John Orr**

309 Solidified Natural Rubber Latex (NRL) as a Joint Material in Foldable and Kinetic Structures
Malik Qdeimat, Kevin Moreno Gata and Martin Trautz
Keywords: Foldable structures, Natural rubber latex, Structure connections, Kinetic structures, Elasticity, Renewable material, Sustainability

189 A Paradigm In Digital Detail Design For A Complex Timber Framework
Timo Claus and Kaspar Ehrhardt
Keywords: Timber Construction, Building in Existing Structures, Parametric 3D Planning, BIM, Data based Modelling, Digital Fabrication, Rhino, Grasshopper

64 Experimental research on mechanical properties of laminated veneer lumber connected with wood dowels
Haiyan Fu, Minjuan He and Zheng Li
Keywords: Laminated veneer lumber, LVL, Dowel laminate timber, Dowel, Dowel-type timber joints, Beam, Failure mode, Joint shear properties, Flexural behavior

327 Meristem : Connectors for Cluster-Laminated Bamboo structures
Hong-Sheng Jiang and Shih-Yuan Wang
Keywords: Bamboo Construction, Connectors, Assemblies, Glued Laminate Bamboo, Lightweight Structures

514 Development of joining details for timber components using long fully threaded screws
Denis Grizmann, Andrija Pranjic and Martin Trautz
Keywords: Timber construction, fully threaded screws, joining details, glulam, CLT

78 Enhancing glulam-fully threaded screw bond durability: Impact of transversal screw reinforcement on creep damage reduction
Andrija Pranjic, Martin Trautz and Denis Grizmann
Keywords: timber construction, fully threaded screws, creep behaviour, lifespan of structure, reinforcement, thin timber elements

186 Exploration of Bacterial Cellulose-Based Biofilms for Compliant Mechanisms in Adaptive Façade Applications
Gozde Damla Turhan Haskara, **Pinar Neseliler** and Yenal Akgün
Keywords: curved line folding, biobased material, bacterial cellulose, adaptive facade

196 Robotic Joining of Oblique Dowels – Precision Analysis and Calibration
Felix Schmidt-Kleespies, Niels Clasen, Laurenz Andritz and Alexander Stahr
Keywords: robotic manufacturing, design for disassembly, mono-material construction, resource efficiency, interlocking joints, beech dowels, woodn nails, prefabricated timber structures

Room: HIL E4 - WG 13 Computational Methods

Moderator: **Kentaro Hayakawa**

93 On improving buckling resistance in structural topology optimization
Tao Xu, Xiaodong Huang, Xiaoshan Lin and Yi Min Xie
Keywords: Topology Optimization, Buckling, Structural Design, Stability

552 Force-serial and Force-parallel Actuation Placement for Topology Optimization of Adaptive Structures
Gennaro Senatore
Keywords: structure-control, optimization, topology, adaptive structures, active structural control, ultralightweight, force-serial actuator, force-parallel actuator

6 Efficient Structural Design of Reconfigurable Spatial Structures by Adopting Aerodynamic Shapes
Stefanos Gkatzogiannis, Marios C. Phocas, Eftychios G. Christoforou, Charis C. Gantes
Keywords: Reconfigurable spatial structures, Reconfiguration shapes, Structural design, Adaptive architecture

70 Method to simultaneously determine the optimal placement and performance of TMDs to minimize the seismic response of spatial structure buildings and study on reducing the analysis load
Kento Fukushima, Katsuto Miyamoto and Shinta Yoshitomi
Keywords: spatial structure, seismic response, optimum design method, TMD, vibration control

162 Natural slope: experimental methods and computational models searching for shape generated by controlled falling sand flows
Martina Ricciardi, Sergio Pone, Salvatore Sessa and Daniele Lancia
Keywords: form finding, sand flows, natural slope, discovering by doing, geometric methods, computational design, self-organized material, developable surface

477 Uncertain analysis of deployable structures with interval parameters based on finite particle and Chebyshev polynomial methods
Yanfeng Zheng, **Siyuan Li,** Yanbin Shen and Yaozhi Luo
Keywords: deployable structure, dynamic response, uncertainty, finite particle method (FPM), Chebyshev polynomials method

526 Slabs with stress-aligned ribs: computational validation of their structural efficiency
Victor Ramirez, Kevin Moreno Gata, Andrija Pranjic and Martin Trautz
Keywords: Ribbed slabs, Stress-aligned ribs, Isostatic ribs, Principal stress lines, Structural analysis, Computational design

573 Data evaluation of a Form-Force-Pattern mechanism; A Machine learning approach on stripe segmentation of minimal shell structures
Pablo Baquero, Effimia Giannopoulopu and Kalliopi Valsamidou
Keywords: Stripes, Segmentation, Stress lines

Room: HIL E6 - WG 18 Life-Cycle Design and Assessment of Shell and Spatial Structures

Moderator: **Olivier Baverel**

486 Efficiency and attitude: On the relationship between lightweight structures and sustainability
Maren Zywietz and Annette Bögle
Keywords: conceptual design, lightweight structures, sustainability, sustainable construction

527 Comparative Life Cycle Assessment (LCA) of Membrane and Grid Shell Structures: A Case Study Analysis
Zehra Eryuruk, Marijke Mollaert, Danny Van Hemelrijck and Lars De Laet
Keywords: Life Cycle Assessment, Comparative Analysis, Membrane Structure, Grid Shell Structure, Environmental Impact, Sustainability, Architectural Design

335 Sustainable Design Synthesis on Discrete Free-From Structures Utilizing Existing Building Objects
Yu Zhang and Kristina Shea
Keywords: Generative Design, Sustainable Structures, Discrete Assembly, Life Cycle Assessment, Combinatorial Optimization, Finite Element Analysis, Rigid Body Equilibrium

339 Building acoustic analysis of doubly curved beam-like shell floors made of CFRP prestressed concrete and its integration into an interdisciplinary optimisation tool
Ahmad Eiz Eddin, Paul Merz, Max Dombrowski, Lucas Heidemann, Steffi Reinhold, Jamila Loutfi and Berndt Zeitler
Keywords: building acoustic simulation, impact sound pressure level, sound transmission loss, doubly curved beam-like shells, optimisation tool, embodied carbon

374 "Design-In Waste" for circular architecture: a conceptual framework
Bing Yang, Weisheng Lu and Liang Yuan
Keywords: Circular Architecture, Material Reuse, Design-In Waste, Sustainable Design

400 A Deep Learning-based Compressive Sensing Method for Vibration Monitoring of Spatial Structures
Guan-Sen Dong, Hua-Ping Wan and Yaozhi Luo
Keywords: Structural health monitoring, compressive sensing, deep learning

32 Research on Seismic Performance of Super-Large Span Megalatticed Structures Retrofitted with GFRP
Bo Huang and **Xudong Zhi**
Keywords: super-large span, mega-latticed structures, seismic performance, GFRP, function loss, static stability

367 How sustainable are our typical structural shapes and materials?
Petr Vegh
Keywords: Sustainability, Embodied Energy, Operational Energy

Room: HIL E7 - WG 6 Tension and Membrane Structures

Moderator: **Niccolo Baldassini**

463 Experimental study on the In-Plane load-deflection behavior and wrinkling of highly inflated fabric arches
Runsheng Zhao, Xiongyan Li, Xiaorui Liu, Wei Wang and Suduo Xue
Keywords: Arches, Experiment, Load-deflaction, wrinkling

426 Conceptual design of tensile membrane structures using interactive optimization
Allan L Marbaniang, Sounak Kabasi, **Siddhartha Ghosh** and Ajmal B Mahasrankintakam
Keywords: tensile membrane structures, conceptual design, interactive optimisation, generative design

428 Reliability analysis of tensile membrane structures using a metamodeling approach
Ajmal B Mahasrankintakam, **Siddhartha Ghosh,** Allan Marbaniang, Sounak Kabasi
Keywords: tensile membrane structures, reliability analysis, uncertainty, metamodeling

52 Flat membranes: Achieving dimensions using low strength porous fabrics
Oriane Guidet, Niccolo Baldassini, and Klaas De Rycke
Keywords: Tensile structures, Membranes, Large span facades, Flat facades, R&D

115 Optimization Study on Double Layer Cable System Structure of Marine Photovoltaic Power Generation Support
Zhang Gaoming, Shen Zhaoxu, Ma Ming
Keywords: Photovoltaic power generation, double-layer cable system, flexible support, ice load, marine photovoltaic

136 Collapsible Scissor Structured Panels with Knit Membranes
Virginia Melnyk
Keywords: Knitting, Transformable Structure, Tensegrity, Membranes

214 Progressive collapse analysis of Geiger type cable domes with partial CFRP cables
Weijing Zhang and Yizhou Hu
Keywords: Cable dome, CFRP cables, Progressive collapse, Nonlinear dynamic analysis, Collapsed area

Room: HIL E8 – WG 8 Metal Spatial Structures

Moderator: **Paolo Beccarelli**

466 Structural Design of Sail-shape Steel Structure of Beijing Subcenter Station
Qiang Zhang, Tang Hu, Ming Ma and Zhao Pengfei
Keywords: Beijing Sub center Station, Sail-shape Steel Structure, Spring member

516 Structural behavior of lantern-shaped reticulated shell considering skin effect of perforated aluminum alloy plate
Xiaonong Guo, **Zilin Tang** and Liyan Ji
Keywords: aluminum alloy reticulated shell, perforated aluminum alloy panel, skin effect

16 Investigation on the Influence of the Cross-Sectional Geometry on ¨the Mechanical Response of Lattice Steel Systems Produced with Wire-and-Arc Additive Manufacturing
Vittoria Laghi, Lidiana Arrè, Michele Palermo, Giada Gasparini and Tomaso Trombetti
Keywords: Additive Manufacturing, Steel structures, Lattice structures, Computational design, Mechanical properties

145 Design-to-Production Process for Large-Scale Inflated Tensegrity Artwork
Enrico Pontello, Roberto Maffei and Paolo Beccarelli
Keywords: inflated steel, steered buckling, digital simulation, tensegrity structure

28 Research of lateral impact resistance and axial residual axial bearing capacity of high-strength circular steel tube
Ximei Zhai, Kaiyun Yang and Huaxiao Gao
Keywords: Impact, High-strength steel, Residual bearing capacity, Tube, Stable bearing capacity

65 Seismic Response of Steel Plate Shear Wall and Timber Frame Hybrid Structures
Zhen Wang, Zheng Li and Minjuan He
Keywords: Steel-timber hybrid structure, Timber frame, Steel plate shear wall, Seismic design, Nonlinear analysis

372 Applicability of available design methods for axial compressive bearing capacity of concrete-filled bimetallic steel tube
Zhuo Zeng, Huiyong Ban and Peng Dai
Keywords: Concrete-filled bimetallic steel tube, Stub columns, Axial compression, Experiment, Design method

609 Coupling effect on cumulative damage model and hysteretic model of steel beam-column
Letian Hai, He Zhao and Boshan Chen
Keywords: Seismic performance, Cumulative damage model, Hysteretic model, Steel structure

Room: HIL E9 – WG 12 Timber and Bio-based Spatial Structures

Moderator: **Martin Trautz**

411 Spiral CLT-concrete composite stair clear spans 21m (70 ft)
Mark Skepasts / Lucas Epp, Lukas Gispert and Gerald Epp
Keywords: Timber-Concrete Composite, Timber Engineering, Finite Element Analysis, Freeform Structures, Vibration, Curved CLT, Doubly curved timber, Mass timber

509 Building with Naturally Grown Timber: Circular Design in Forest Construction – A pedestrian Bridge Case Study
Kevin Moreno Gata, Cedric Wehren, Sven Klinkel and Martin Trautz
Keywords: raw-timber structures, circular design, forest construction, off-knot, pedestrian bridge

406 Post-analysis of Wisdome Stockholm: a comparative study of building model versus constructed geometry
Evy Laura Slabbinck, Stefan Rick, Moritz Niebler and David Riggenbach
Keywords: post-analysis, timber gridshell, interdisciplinary solutions, wood-only constructions, freeform structures

140 Reciprocal Lightweight Structures with Natural Fiber Biocomposite Profiles through Computational Design and Case Studies Validation
Evgenia Spyridonos, Alexander Reiner, and Hanaa Dahy
Keywords: natural fibre pultruded profiles, biocomposites, reciprocal structure, lightweight structure, agent-based modelling

283 Study on a Development of Wooden Parallel Chord Truss Structure with Lumber in Mori-Machi, Hokkaido
Yousuke Inaba, Masahiko Toda, Ryosuke Tomitaka, Yoshinori Ohashi, Shoji Suzuki and Masamichi Sasatani
Keywords: Parallel Chord Truss, Dimension Lumber, Laminated Timber, Assembled three lumbers of different species, Use both Drift Pin and Screw

409 Innovative Truss Design for Long-Span Timber Vaults: The Tianfu Agricultural Expo
Lucas Epp, Gerald Epp and Leon Treder
Keywords: long-span, mass timber, glulam, arches, hybrid truss, timber-steel hybrid, parametric, Cui Kai, Vierendeel truss, structural efficiency

Wednesday

Slot 7: 14:00-15:30

Room: HIL E3 - WG 21 Advanced Manufacturing and Materials

Moderator: **Rupert Maleczek**

88 Construction of shells by active bending of flexible concrete
Johannes Berger, Rupert Maleczek and Mathias Bank Stigsen
Keywords: active bending, flexible concrete, construction method, form finding

319 Foam and solvent: a low-tech self-forming casting technique for the production of double-curved asymmetrical concrete panels
Ivana Susic and Efilena Baseta
Keywords: Concrete casting, Flexible Mould, Double-Curved Surfaces, Formwork, Extruded Polystyrene, Gravity-Informed, Self-forming

563 Numerical Investigation of 3D-printed Spinal Braces
Iason Rossetos, Stefanos Voulgaris, George Kazakis, **Charis Gantes** and Nikos Lagaros
Keywords: spinal brace, nonlinear finite element analysis, 3D printing, experimental testing

228 Towards the control of doubly curved active textiles through graded pre-stretching and 3D printing
Sebastian Lettner, Efilena Baseta and Marco Palma
Keywords: active textiles, double-curved shells, non-uniform stretching, graded material thickness

268 Stiff and soft deformation of a 3D-printable tensegrity-inspired metamaterial based on expanded octahedron
Anna Al Sabouni-Zawadzka, Wojciech Gilewski and Adam Zawadzki
Keywords: tensegrity, mechanical metamaterial, extremal material, 3D printing

192 Evaluation of the wind load history of environmentally exposed ETFE foils
Ketankumar Solanki, Torsten Balster and Carl Maywald
Keywords: ETFE, Mechanical properties, bi-axial hysteresis, Wind load

512 Towards Controlled Frustration: Parameterization of Self-Morphing Clay
Ofri Dar, Eran Sharon and Arielle Blonder
Keywords: Frustrated-matter, Material-system, Material programming, Self-morphing, Parametric

534 Stimulated Soil for Continuous Shell Structures
Roni Hillel, Tom Shaked, Michael Tsesarsky and Aaron Sprecher
Keywords: MICP, Sustainable materials, Locally sourced soil, Shell structures, Robotic Fabrication

114 HoloMasonry: Complex Brick Assemblies Constructed with HoloLens
Rui Liu and Frederick Lucak
Keywords: Masonry, Complex Geometry, Mixed Reality

Room: HIL E4:- WG 15 Structural Morphology

Moderator: **Lennert Loos**

362 Experimental and numerical study of a funicular concrete beam prototype
Maximilian Ororbia, Hua Chai, Yefan Zhi, Jorge Chacon, Joseph Yost, Mathias Bernhard, Fahimeh Yavartanoo, Javier Tapia, Damon Bolhassani, Mylene Bernard, Leon Trousset, Karolina Pajak, Blaise Waligun, Paul Kassabian, Masoud Akbarzadeh
Keywords: Funicular beam, Embedded periodic anticlastic surfaces, Concrete 3D-printing, Post-tensioning, Four-point bending test

505 Ultra-compact structure with snap-through behaviour for multi-stability
Ruta Stankeviciute and Jun Sato
Keywords: ultra-compact, deployable, snap-through, eigenvalue, buckling analysis, multi-stability

286 Reconfigurable shellular structures assembled from strip modules
Kanata Warisaya and Tomohiro Tachi
Keywords: shellular structure, tessellation, modular construction, sheet material

291 Reconfigurable Inflatable Surface Structure with Tension String Patterns
Masaya Todo, Nozomu Sudo, Tomohiro Tachi, Yoshihiro Fukushima and Kotaro Imai
Keywords: structural morphology, inflatable structure, reconfigurable structure, computational design

442 Designing of three-dimensional structures based on earwig wing folding
Chisaki Kitajima, Kazuya Saito and Kaoru Suehiro
Keywords: Origami, Biomimetics, Insect Wing, Deployable Structure, Form Finding, Hangai Prize applicant

80 A comparative analysis of 3d printed gridshell structures using finite element models and experimental load-deflection tests.
Samar Malek, Charlotte Ryan and Jonathan Slager
Keywords: gridshells, additive manufacturing, experimental load-testing, finite element analysis

104	Capture, optimization and transformation of physical funicular models in the digital environment: Methodological framework and application in structural design **David Afonso,** Alexandrino Diogo and João Fialho	*Keywords:* Physical models, Form-Finding, Polyfuniculator, Photogrammetry, 3D Scanning, Motion-Capture, Structural Design and Analysis, Reverse Engineering
18	Robust funicularity of arches via adaptive shape control **Peter L. Varkonyi** and Andres F. Guerra Riano	*Keywords:* funicular, arch, shape control, adaptive structures
205	Lightweight and Floating: Optimizing the Material Usage and Force Flow of Spatial Structures **Zane Schemmer** and Josephine Carstensen	*Keywords:* topology optimization, tensegrity, multi-material, mixed-integer optimization

Room: HIL E6:- WG 18 Life-Cycle Design and Assessment of Shell and Spatial Structures

Moderator: **Selina Bitting**

511	A bio-based falsework system for the circular construction of shell structures **Selina Bitting,** Francesco Ranaudo, Andrea Menardo, Tom Van Mele and Philippe Block	*Keywords:* Mycelium-bound composites, MBC, bio-based, waste, falsework, formwork, circularity, shell structures, spatial structures
277	Design-Stage Carbon Reduction Pathways for Steel Structures **Ramon Weber**, Juliana Berglund-Brown, John Ochsendorf, Christoph Reinhart and Caitlin Mueller	*Keywords:* geometric optimization, reuse, steel structures, life cycle analysis, sustainable design strategies
201	Reducing the environmental impact of buildings through stone masonry structures **Pierre Navaro Auburtin,** Myriam Saadé, Manuel Manthey, Mathilde Loüerat, Jean-Luc Martin and Olivier Baverel	*Keywords:* Stone, Vault, LCA, Multicriteria, Design
137	Microscopic characterization of weathering aging ethylene tetrafluoroethylene (ETFE) foils **Jianhui Hu,** Jian Zhang, Pujin Wang, Chengjun Gao and Wujun Chen	*Keywords:* ETFE foil, membrane structure, microscopic characterization, material mechanics, aging performance
242	Material Saving Analysis of Shell Structure -Taking the Structure of Solar Ark 3.0 in Solar Decathlon China 2022 as an example **Haochen Xu,** Junjun Zhang and Hong Zhang	*Keywords:* Shell structure, Material flow analysis, Life-cycle assessment, Building performance
328	Designing with partially disassembled trusses: An automated approach **Albertine Van Marcke,** Vittoria Laghi and Josephine Voigt Carstensen	*Keywords:* Steel trusses, Steel reuse, Structural optimization, Genetic algorithm, Circular economy
614	Recyclability of Earth-Fiber Materials for 3D Printing **Olga Beatrice Carcassi,** Yierfan Maierdan, Shiho Kawashima and Lola Ben-Alon	*Keywords:* Earthen materials, Biobased materials, Compressive strength, LCA, Additive manufacturing, Recyclability, Regenerative design

Room: HIL E7 – WG 6 Tension and Membrane Structures

Moderator: **Lars De Laet**

155	Research on the impact of cross cable nets on air-inflated membrane structures and methods for optimized arrangement **Shanshan Shen**, Yijie Zhang, Xiangye Xu, Jinghai Gong and Guozhi Qiu	*Keywords:* air-inflated membrane structures, cable net arrangements, optimized method
337	Design of restrained pneumatic formwork – Inverse form finding and materialisation for free form geometries **Chaoyu Du**, Ziqi Wang, Tom Van Mele and Philippe Block	*Keywords:* pneumatic structure, form-finding, optimisation, materialisation, inverse design
380	Effect of cable-membrane contact on mechanical properties of air-supported membrane structures **Xinyu Xu** and Xiaoying Sun	*Keywords:* air-supported membrane structure, cable–membrane contact, wind-induced response analysis, parameter analysis
107	Experimental and numerical study on fire-induced pressure variation of the air-supported membrane structure **Yaning Zhang**, Ying Sun, Guoliang Wang, Yang Yu and Zhenggang Cao	*Keywords:* small size air-supported membrane structure, Fire test, Internal pressure variation
119	Experimental study on the dynamics of a pull-tab multi-chamber arched inflatable membrane structure **Shaochen Yang,** Zilong Zhou and Wujun Chen	*Keywords:* pull-tab multi-chamber arched inflatable, Vibration characteristics, Internal pressure

564 Design and control of robotic shape-morphing pneumatic-hybrid structures for architectural and design applications
Valentina Soana, Shahram Sabery, Federico Bosi and Helge Wurdemann
Keywords: lightweight, pneumatics, soft robotics, adaptive

67 Designs of self-rigidizable inflatable habitats for construction in extreme environments
Qinyu Wang, Peng Feng and Kaspar Jansen
Keywords: inflatable habitats, rigidization, shape memory polymer (SMP), multi-layer jamming system, extreme environments, variable stiffness components

Room: HIL E8 – SS13nm Numerical methods for geometry, form-finding and optimization of lightweight structures

Moderator: **Pierre Latteur, Josephine Carstensen**

79 MUSCLE: a new software for the interactive design of tensegrity structures
Jonas Feron, **Basile Payen**, Joao Almeida, and Pierre Latteur
Keywords: Muscle, Tensegrity, SVD, self stress modes, Grasshopper

150 Envelope Optimization: Shape- and Thickness-Optimization for multiple Load Cases
Patrick Schäferling and Matthias Beckh
Keywords: Form-finding, Optimization, Dynamic Relaxation, Particle-Spring Method, Multi-load cases, Variable loads

110 Comparing design outcomes of reinforced concrete elements designed using topology optimization
Jackson Jewett and Josephine Carstensen
Keywords: Topology optimization, digital concrete, structural optimization, low-weight design

184 Topology Optimization of Two-dimensional Tensile Trusses using Different Materials
Lidong Zhu and Jingyao Zhang
Keywords: Topology optimization, Prestress optimization, Tensile truss, Genetic algorithm, Plastic design

421 Topology optimization of trusses considering local buckling constraints of bars
Qi Cai and Yiyi Zhou
Keywords: Truss, topology optimization, diverse design, local buckling.

111 Generation of planar quadrilateral mesh using tensegrity model
Jingyao Zhang and **Makoto Ohsaki**
Keywords: Form-finding, PQ mesh, Tensegrity, Self-equilibrium

152 The effect of minimized orientation of members in connections on the structural behavior of free-form lattice space structures
Ahmad Sobhi, **Hadi Esmailnejad,** Mohammad Reza Chenaghlou and Karim Abedi
Keywords: Free-forms, Space structures, Orientation of Members, Twist angles, minimized orientation, Stability behavior

336 A New Lightweight Porous Structures for Reusable Energy Absorption in Heavy-loaded Planetary Landers
Chengbo Cui, Jianguo Cai and Meng Li
Keywords: Planetary Landers, Reusable Energy-absorbing, Shape Memory Alloy, Miura Origami, Machine learning

358 The effect of post-tensioning on the behavior of small-scale 3D-printed concrete beams
Damon Bolhassani, Fahimeh Yavartanoo, Javier Tapia, Masoud Akbarzadeh, Maximilian E. Ororbia, Hua Chai, Yefan Zhi, Mylene Bernard, Leon Trousset, Karolina Pajak, Blaise Waligun and Paul Kassabian
Keywords: Experimental testing, post-tensioning, Periodic anticlastic funicular beam, 3D concrete printing

Room: HIL E9 – WG 20 Teaching of Shell and Spatial Structures

Moderator: **Alireza Behnejad, Annette Bögle**

69 Les Petits Constructeurs: archs, vaults and domes explained to children
Sylvain Ebode, Marc Leyral, Ludovic Regnault and Quentin Chef
Keywords: pedagogy, arches, vaults, domes, childhood, virtual reality, structural games

167 Structural design pedagogy under the embodied perception: an equilibrium-based approach for architecture students
Shuaizhong Wang
Keywords: Structural education, Structural design, Embodied perception, Graphic statics, Equilibrium, Neuroscience

361 Correlated physical and parametric FEM modeling for computational design and engineering workflows – a way to facilitate understanding of structural behavior
Miriam Dall'Igna and Marcio Sequeira de Oliveira
Keywords: Teaching Structural Behaviour, Physical Structural Models, Computational Parametric Models, Form-finding, Finite Element Method

118 Progress and trends in lunar habitat construction research based on bibliometric analysis
Jiang Jiayang, Mei Hongyuan, Li Shuqi, Yu Zefeng and Hong Yang
Keywords: lunar habitat, construction, additive manufacturing, in situ resource utilization

171 Architectural Tectonics and Structural Systems
Shin Yokoo
Keywords: Architectural tectonics, Architectural student, Archi-Tectonics

507 Sustainability by design: a holistic approach to integrating sustainability into structural engineering education
Celina Hunschok and Annette Bögle
Keywords: Sustainability, Structural Education, Education for Sustainable Development, Life-Cycle-Assessment, Parametric Design

Room: HIL E3 – WG 21 Advanced Manufacturing and Materials

Moderator: **Grace Melcher**

267 3D Printing ICONs Cosmic Pavilion: A Case Study in Cementitious Extrusion of Unsupported Cantilevers
Grace Melcher, Andy Rauch, Melodie Yashar and Jason Ballard
Keywords: 3D printed structures, cementitious extrusion, printed cantilevers, shell structure

265 Using WAAM Metal Distortion for Sheet Metal Forming
Cedric Wehren M.Sc., Alex Seiter M.Sc., Univ. Prof. Dr.-Ing. Martin Trautz, Johannes Kellerwessel M.Sc., Dr. Rahul Sharma M.Sc. and Univ. Prof. Dr.-Ing. Uwe Reisgen
Keywords: WAAM, material behavior prediction, sheet metal forming, welding

106 Cyclic behavior study of LY160 steel shear panel damper
Ziran Xu, Minger Wu, Jiachun Cui and Yuxiao Wu
Keywords: Low-yield-point steel shear panel damper(LSSPD), Test study, Cyclic behavior, Energy dissipation, Overstrength

504 InNoFa 2.0 | Topological adaptive non-periodic infills for MacroSLM façade nodes
Martin Dembski, Alexander Stahr, Martin Erler and André Streek
Keywords: additive manufacturing in architecture, complex geometry, facade, FLEX, InNoFa, MakroSLM, metall node, non-periodic infill, parametric design, topological optimization

156 Integrated methods for smart design and CNC manufacture of reticulated structures with bolt-ball joint
Yijie Zhang, Xiao Dong, Rui Chen, Jinghai Gong, Guangyong Li, and Guozhi Qi
Keywords: reticulated structure, bolt-ball joint, smart design, CNC, integrated design and manufacture

97 Design and high precision manufacturing of a structural glass scaffolding using glued connection
Paul Covillault, Klaas de Rycke and **Niccolo Baldassini**
Keywords: Structural glass design, Structural glazing, Glued glass, Stainless steel moulding, High precision manufacturing, Glass connection, Glass testing, Predictability, Art piece

224 Puffer Dome
Mirco Becker, Philipp Mecke, and Momo Wittmer
Keywords: space frame, inflatable structure, 3D-printing, universal joint

285 NonShell: Porous Structure by composite fabric formwork system
Wei Che Lo and Shih Yuan Wang
Keywords:

Room: HIL E4 – WG 15 Structural Morphology

Moderator: **Clemens Preisinger**

577 Design-to-construction workflow for free-form Abeille stone structures
Yousef Anastas, Maurizio Brocato and Olivier Baverel
Keywords: Stone structure, stereotomy, abeille, free form, computation, advanced fabrication

384 Computational Design and AR-assisted Assembly of Infinitely Reusable Temporary Structures
Chenming Jiang, Yi Hsiu Hung, Ziqi Wang, **Yijiang Huang**, Aurèle L. Gheyselinck and Petrus Aejmelaeus-Lindström
Keywords: Infinitely Reusable Kit of parts, Reconfiguration for multipurpose designs, Assembly-aware Design

447 Fold and Snap - Flatpacking a wooden Beam
Rupert Maleczek, Marcus Bernhard, Roland Maderebner and Clemens Preisinger
Keywords: Curved folding, Structural origami, applied folding, innovative fabrication, fabricating flat

460 Structural Design and Analysis of Marinaressa Coral Tree
Daria Kovaleva, Ivan Tomovic, Oliver Gericke and Lucio Blandini
Keywords: lightweight concrete structure, topological optimization, conformal lattice structure, sustainable production methods, 3d-printed sand formwork

243 The Wadi Cascade - retaining walls for an iconic landscape feature
Julien Tanant, Serge Saade, Antoine Abboud, Aaron Hill, Thomas Daneels, Peter Harrison, Emre Cestel
Keywords: Computational Design, Structural Design, Retaining walls, Reinforced concrete, Landscape architecture

494 Research on the TSUNAMI shelter using the polyurea resin
K. Teraoka, O. Takahashia, Y. Kaitob, T. Aokic, H. Nakazawad, Y. Onodae and Y. Kawamata
Keywords: disaster, Tsunami, shelter, analysis, polyurea

62 Fracture experiment of arch String Crescent Structure
Akira Tanaka
Keywords: String Crescent Structure, Fracture experiment, Preferentially Broken Member, Connect Member, Support Condition, Fall Block

87 Self-forming pedestrian arch bridge based on bending-active concept
Jiacheng Zhao and Peng Feng
Keywords: bending-active, pedestrian arch bridge, form-finding, glass fiber-reinforced polymer (GFRP), buckling mode

472 A Foldable Temporary Shelter Design
İrem Yetkin, Feray Maden, Seda Tosun, Yenal Akgün, Özgür Kilit, Gökhan Kiper, Koray Korkmaz and Mustafa Gündüzalp
Keywords: Deployable structures, Foldable plates, Forced migration, Temporary shelters, Transformable structures

Room: HIL E6 – WG 18 Life-Cycle Design and Assessment of Shell and Spatial Structures
Moderator: **Heidi Silvennoinen**

54 Adaptation of portal frames topology for a broader reuse potential
Chloé Ruda, François Lecompte, Cyril Douthe, Myriam Saadé and Olivier Baverel
Keywords: Reuse, Structural design, Industry-oriented design, Prospective scenarios, Life Cycle Assessment, Environmental Impact, Pareto optimization

12 Design and Embodied Carbon Optimisation of a Composite Floor System with Thin Concrete Shells on a Beam Grid
Amila Jayasinghe, Emmanuel Momoh, Mohammad Hajsadeghi, John Orr, Raffaele Vinai, Prakash Kripakaran and Ken Evans
Keywords: thin shell floors, shape optimisation, embodied carbon, composite floor systems

470 Design approach for a post-tensioned funicular concrete beam
Hua Chai, Maximilian Ororbia, Yefan Zhi, Ryan Welch, Billie Faircloth, Fahimeh Yavartanoo, Damon Bolhassani and Masoud Akbarzadeh
Keywords: Form-finding, graphic statics, volumetric modeling, concrete floor design, LCA, 3D concrete printing

471 Towards Automated Building Life Cycle Assessments: A Novel Approach Using Large Language Models and the COMPAS Framework
Li Chen, Heidi Silvennoinen, Catherine De Wolf, Daniel Hall, Tom Van Mele and Philippe Block
Keywords: digital fabrication, BIM, LCA, interoperability, Open-source, AEC, slab, embodied impacts, COMPAS, software integration

521 Development of a Prefabricated Arched Slab System for a Pedestrian Pathway: A Sustainable Strategy in the Huasco Landscape, Chile
Cristian Calvo-Barentin, Osvaldo Moreno Flores, Claudia Eugenin and Estefania Loyola
Keywords: Prefabricated Arched Slabs, Sustainable Construction, Tailings Reuse, Ecological Landscaping

57 Consideration of resiliency in the repair and completion of a damaged cooling tower
Phillip Gould
Keywords: Cooling Tower, Repair of Damaged Shell, Resiliency

574 An early design stage parametric exploration of integrated concrete funicular floor element and thermal mass performance for carbon footprint reduction
Zherui Wang, Hua Chai, Xiaoxiao PENG, Ryan WELCH, Masoud Akbarzadeh and Dorit Aviv
Keywords: Form-finding, graphic statics, multi-criteria design, structural thermal mass, carbon reduction

Room: HIL E7 – WG 6 Tension and Membrane Structures
Moderator: **Lars De Laet**

216 Long-term weathering durability of ETFE membranes with controlled thermal and optical properties
Hiroshi Aruga and Kouichi Oda
Keywords: ETFE, exposure test, thermo-optical properties, filler

247 Correlation between the uni- and biaxial tensile behaviour of ETFE-foils for rationalised modelling of multiaxial stress states
Felix Surholt, Jörg Uhlemann and Natalie Stranghöner
Keywords: ETFE-foil, tensile behaviour, material characterisation, uniaxial, biaxial, multiaxial, correlation

257 Minimum Load-Bearing Capacities of ETFE Area Weld Seams
Dominik Runge, Jörg Uhlemann and Natalie Stranghöner
Keywords: ETFE-foils, area weld seams, load-bearing capacity, FprCEN/TS 19102

76 Experiments on the structural behaviour of tri-layer and two-chamber ETFE
Xuetao Zhao, Wujun Chen, Bing Zhao, Ying Zhang and Jing Cai
Keywords: tri-layer and two-chamber ETFE cushion, progressive suction load, structural behaviour

237 Characterisation and Modelling of ETFE Membranes for Tensile Structures
Luis Miguel Seixas, Alessandro Comitti, Massimo Penasa and Federico Bosi
Keywords: ETFE, Membranes, Viscoelastic, Viscoplastic, Yield Criterion, Experimental characterisation, Numerical implementation

448	Limits of ISO 527-1 results for the simulation of environmental influences on the design with ETFE **Torsten Balster,** Robert Neu and Carl Maywald	*Keywords:* membranes, uniaxial and biaxial tensile test, testing speed, strain rate, wind loads, environmental test conditions
270	An ETFE canopy above IGR metro station Aubry Simon, **Aymeric Perret du Cray** and Hervé Tourlet	*Keywords:* ETFE, Membrane, Roof, Bicycle wheel structure
197	Inaccuracy of Testing Speed in Determination of Tensile Properties of ETFE Membranes according to ISO 527 **Delche Lazarev**, Torsten Balster and Carl Maywald	*Keywords:* membranes, tensile test, testing speed, strain rate, testing inaccuracy, material specifications

Room: HIL E8 – SS13ng Next Generation Parametric Design

Moderator: **Ann-Kathrin Goldbach, Peter von Buelow**

89	People-Led Digitalisation : Lessons learned from two concrete shell research projects **Paul Shepherd**	*Keywords:* people-led, concrete, shell, design
405	Interdisciplinary optimisation tool for doubly curved beam-like shell floors made of CFRP prestressed concrete **Jamila Loutfi**, Max Dombrowski, Paul Merz and Ahmad Eiz Eddin	*Keywords:* parametric design, embodied carbon, material costs, load-bearing capacity, moment-curvature relationship, sound insulation, genetic algorithm
413	Design and Fabrication of Structures with Graphic Statics and Augmented Reality **Norman Hack,** Carsten Jantzen, Yinan Xiao, Julian Tesche, Karam Mawas and Pierluigi D'Acunto	*Keywords:* Augmented Reality, Vector-based graphic statics, on-site construction, multi-user collaboration
529	The Bog Characters: A New Generation of High Voltage Power Pylons **Siim Tuksam**, Sille Pihlak, Adam Orlinski and Moritz Heimrath	*Keywords:* power pylon, parametric design, structural optimisation, genetic algorithms, contextual design, infrastructure
608	Predicting robotic constructability in early design of a panelized structure: a surrogate model for a mobile robotic arm Seyed Hossein Zargar and **Nathan Brown**	*Keywords:* Autonomous construction, robotic constructability assessment, surrogate modelling, multi-objective optimization, design space exploration
221	Applications of an LLM to Scale and Automate Computational Workflows for Civil Structural Design **Nicholas Williams**, Sujal Kodamadanchi-rayil Suresh, Luke Hughes, Brian Kileen, Theodore Galanos	*Keywords:* Computational design, Digital practice, Parametric design, Engineering design software
353	Fabrication-Aware Design for 3DCP Shells Using Genetic Optimization **Jurij Licen** and Taole Chen	*Keywords:* 3D concrete printing, genetic algorithm optimization, complex shell geometry
560	Digitally engineered stone masonry building structures Matthew Gilbert, Isuru Nanayakkara, Helen Fairclough, Linwei He, Serena Amodio, Andrew Liew James Rae-Smith and **Jian Zhang**	*Keywords:* Masonry, Construction, Parametric design, Limit analysis, Optimization

Room: HIL E9 – WG20 Teaching of Shell and Spatial Structures

Moderator: **Alireza Behnejad, Annette Bögle**

226	Deployable Scissor Mechanism for Responsive and Transformable Facade Design **Ladan Vojdanzade** and Katayoun Taghizade	*Keywords:* Transformable, Responsible, Façade, Scissors Mechanism, Training, Architecture
310	Form & Force: teaching form-finding and fabrication of complex geometry through the design and construction of a structural sculpture Lennert Loos And **Abel Groenewolt**	*Keywords:* Architectural Education, Form-Finding, Structural Design, Tensegrity, Collaborative Learning, Interdisciplinary Approach.
59	Robot supported Wire Arc Additive Manufacturing – Using dot-by-dot printing for lattice column structures **Benedikt Waldschmitt** and Jörg Lange	*Keywords:* metal spatial structures, lattice columns, WAAM, dot-by-dot printing, design-to-manufacturing workflow
173	Proposal for a Responsive Canopy Integrating Curved Line Folding Technique and Cable-Driven Systems Pinar Neseliler and **Yenal Akgün**	*Keywords:* curved line folding, responsive umbrella, cable-bending systems, responsive architecture

Thursday

Slot 9: 9:30-11:00

Room E3 - WG 21 Advanced Manufacturing and Materials

Moderator: **Ioan Serban Bodea**

363 Segmental Ceramic Hollow Structures: Prefabricated posttensioned columns for ecological urban infrastructures.
Juan Jose Castellon and Tianle Chen
Keywords: structural design, segmental hollow structures, ceramics, subtractive manufacturing, robotic fabrication

298 Phoenix 3d-concrete-printed bridge - Falsework system and construction process development
Ioan Serban Bodea, Alessandro Dell'Endice, Vasilis Aloutsanidis, Theo Bürgin, Tom Van Mele,Philippe Block
Keywords: Circularity, Unreinforced masonry, 3D concrete printing, Discrete element modeling, Computational design, Digital fabrication, Digital construction

424 Reimagining Design for a Light Environmental Impact: The Paper Composition Pavilion
Maren Zywietz, Karsten Schlesier,**Vincent Stiehle,** Vincent Krauss, Anna Plate, Henrik Stamm, Anika Wallbrecher, Ahmad Bawar And Sara Mohammadi
Keywords: research pavilion, circular economy, lightweight structures, sustainability, alternative building materials

210 Hierarchical 3D-Printed Truss Structure with Global Stability Constraints
Yizhuo Liu and Hao Hua
Keywords: Hierarchical Structure, Truss, Global Buckling, Additive Manufacturing

393 Design Scheme and Feasibility Study of Self-locking Inflatable Tent Based on Multistable Inflatable Origami
Yikang Zhao, Wujun Chen and **Bing Zhao**
Keywords: inflatable tent structures, multistable inflatable origami, coated fabric membrane metamaterial, deployment performance, load-bearing capacity

7 Climate Friendly Insulation Based on Biobased Products for IASS 2024
Arno Pronk
Keywords: biobased insulation, avoid moister, feasible

116 Exploiting auxetic confinement for enhancing structural performance of earth-based construction
Jiaming Ma, Hongru Zhang, Ahmed Abdelaal, Ngoc San Ha and Yi Min Xie
Keywords: earth confinement, auxetic material, construction, 3D printing, sustainability

169 Connection Designs between Origami Arrays with Multilayer Planes
Qian Zhang, Jian Feng and Jianguo Cai
Keywords: origami, mechanical metamaterials, connection design

Room E4 - WG 15 Structural Morphology

Moderator: **Ann Christine Sychterz**

231 Multistable Polyhedral Origami Modules for Curved Surface Assembly
Munkyun Lee, Kiumars Sharifmoghaddam and Tomohiro Tachi
Keywords: Multistable origami, Deployable structure, Modular system, Metamaterial, Discrete shell, Lightweight structure, Computational geometry, Structural morphology

482 Origami-Based Developable Membrane Tensegrity Roof
Yuta Shimoda, Sei Hayashi and Yasushi Ikeda
Keywords: Membrane tensegrity structure, Origami, Transformable structure

58 Sensor Placement for Control of a Meter-Scale Origami Structure
Ann Sychterz and Angshuman C Baruah
Keywords: Origami, Actuation, Dynamic relaxation, Sensor placement

120 Counting-up and classification of all patterns of singular generalized Miura-ori
Hiroyuki Tagawa
Keywords: Singular generalized Miura-ori, Arc-shaped Miura-ori, Spiral-shaped Miura-ori, Origami, Rigid flat-folding, Deployable structure

133 Origami-based flat foldable structure with non-flat singular point of rigid folding mechanism
Kentaro Hayakawa and Makoto Ohsaki
Keywords: Rigid origami, Flat foldable, Thick panel, Singular state

229 Preliminary research on the shape determination approach of tubular curved origami structures
Tianhao Zhang and Ken'Ichi Kawaguchi
Keywords: curved origami, bending deformation, deployable surfaces, architectural geometry, self-stressed state

371 Topology optimization of deployable structures using ground structures generated by tessellation of origami tubes
Sunao Tomita, Hiroki Kobayashi, Shoko Arita, Masato Tanaka, Atsushi Kawamoto, Tsuyoshi Nomura and Tomohiro Tachi
Keywords: Miura-ori, origami tessellation, mechanism, bar-and-hinge model, topology optimization, ground structure

549 Tailoring rigidity of bending-active perforated sheets
Eszter Fehér and Zsófia Gyetvai
Keywords: geometric rigidity, perforated kirigami, kirigami surface, rigidity control

351 Exploring Rigid Plates Integration in Barrel Vault Deployable Scissor Systems
Ahmed Soliman, Tine Tysmans, Lars De Laet and Niels De Temmerman
Keywords: Scissor structures, Deployability, Transformable structures

Room E6 - SS 18 Regenerative Design (WG 18)

Moderator: **Beril Önalan**

294 Reuse-constrained structural form-finding and construction with VGS tool and reciprocal joint: A Case Study on Traditional Chinese Timber Structures
Chi Zhang, Changliang Wu and Yuchi Shen
Keywords: Reuse, Circular economy, Timber structure, Vector-based graphic statics, Structural design, Adaptive structural joint

322 Concrete rubble as a new construction material: panorama of applications to known structural typologies
Maxence Grangeot, Stefana Parascho and Corentin Fivet
Keywords: upcycling, concrete, rubbles

158 WasteBeam – a path for upcycling non-structural wood waste to structural timber beams
Anders Aagaard, **Jon Engholt,** Niels Martin Larsen and Jens Pedersen
Keywords: Timber, Glulam, Waste upcycling, Material testing

451 Bending and Compressive Behavior of a Co-cultivated Mycelium-Bacteria Based Composite
Lynn Hyun Kieffer and Jakob Sieder-Semlitsch
Keywords: microbial co-cultivation, mycelium-bacteria based composite, mycelium, biocementation, structural performance, digital fabrication

520 Enhancing mycelium-based composites: anisotropic material design and mechanical performance
Dana Saez, Gianna Hofman, Denis Grizmann, Anett Werner and Martin Trautz
Keywords: mycelium-based composites, regenerative design, rapid growth, material design, mechanical properties, anisotropic design, sustainable construction practices, innovation in construction materials

Room E7 - WG 6 Tension and Membrane Structures

Moderator: **Salvatore Viscuso**

103 Lightweight structures applied for the conservation of cultural heritage: two case studies in Pompeii, Italy
Salvatore Viscuso, Christian Renan Endara Vargas, Alessia Belotti and Alice Finetti
Keywords: cultural heritage, lightweight structure, membrane architecture, modular design

402 Research and engineering application of the cable supported arch shell structure
Wen Yang, **Tian Qiu**, Liwei Wang, Kejian Xiao, Yuan Feng and Xinan Xiang
Keywords: Hyperbolic paraboloid, cable supported arch shell structure, pre-tension

515 Pop-up Asymptotic Structure with Woven GFRP Rods Fabricated in Mixed Reality
Nicholas Bruscia, **Emily Vollo**, Yau Wai Lam and Huiying Tan
Keywords: Pop-up Structures, Asymptotic Structures, Lightweight Structures, Mixed Reality Fabrication

314 Study on mechanical properties of a 35-meter-span three-dimensional cable-truss flexible photovoltaic support system
Yue Wu, **Yunqiang Wu** and Ying Sun
Keywords: Flexible photovoltaic support system, Finite element simulation, Mechanical properties, Dynamic properties

388 Interactive Design of Structural Membranes Through Mixed Reality
Michihiro Abe, Nicolas Rogeau and Yasushi Ikeda
Keywords: Mixed Reality, Membrane, Flexible Material, Physical Simulation

246 Unlocking Architectural Potential: The Synergy of One Single Model and Meta-Designer in Parametric Innovation
Federico La Russa and Antonio Diaferia
Keywords: Structural Design, Optimization, Computational Design, One Single Model, Free-form, Shell

Room E8 – SS13nG Next Generation Parametric Design (WG 13)

Moderator: **Ann-Kathrin Goldbach**

211 Smart optimization design methods and software for spatial structures derived by parameters
Xiao Dong, Shanshan Shen, Zhining Jiang, Rui Chen, Guangyong Li, Guozhi Qiu and Jinghai Gong
Keywords: smart optimization design, parameter design, carbon neutrality, building material saving, zone-based modeling, node-based modeling

212 Low-carbon optimal design of greenhouses in five climate zones
Yuting Zhong and Ruoqiang Feng
Keywords: Low-carbon design, Multi-task learning, Architectural optimization, Multi-objective optimization

613 Trans-typology design space exploration: Using gradients to inform decision-making in the design of spanning structures
Demi Fang, Sophia Kuhn, Michael Kraus and Caitlin Mueller
Keywords: design space exploration, computational design, early-stage structural design, structural design, conceptual structural design, conceptual design, design decision-making, embodied carbon, performance-driven design

485 Deep learning approach to structural performance prediction of tall buildings in seismic areas
Pooyan Kazemi, Michela Turrin, Charalampos Andriotis, Alireza Entezami, Aldo Ghisi and Stefano Mariani
Keywords: AI-enhanced architectural modeling, Deep Learning, Tall building optimization, Architectural form generation, Time history seismic simulation, Surrogate modeling

295 Farm-Scale Water Storage in Morocco: Coupling Finite Element Analysis and Parametric Optimization for Rectangular Reinforced Concrete Structural Layouts
Raphaël Trézarieu, Jad Sadek and Josephine Carstensen
Keywords: Parametric Optimization, Finite Element Analysis, Embodied Carbon, Python, Water Tank, Column Layout, Shape Optimization

190 A Volumetric Finite Element Method Software for Analyzing Joints in Spatial Structures
Marcin Luczkowski, Sverre Haakonsen, Lars Toppe and Vegard Øyre
Keywords: knowledge based design, finite element method, parametric modelling, structural analysis, joints calculation, algorithm aided design

Room E9 – SS20 Combining high-end digital and low-tech teaching methods for shell and spatial structures within the planetary boundaries (WG20)

Moderator: **Edmond Saliklis**

546 A new type of interlocking stone structures : bridging high-tech design and low-tech manufacturing
Paul Nougayrede, Anahita Mirani, Aly Abdelmagid and Paul Vergonjeanne
Keywords: Interlocking stone structure, Triply Orthogonal Systems of Surfaces (TOS), High-Tech design, Low-Tech manufacturing, Fabrication-aware design, Centring-free assembly, Stereotomy

591 THINNESS: Pedagogical Form Finding Explorations in Eco-Ethical Shell Structures
Alireza Borhani and Negar Kalantar
Keywords: Form-finding Pedagogy, Geometry-based Approach, Catenary, Funicular Shell Structures, Eco-Ethical Construction

27 Discipline and Play, Spatial Form Finding for Students Studying Structural Engineering
Edmond Saliklis
Keywords: Form-finding, stability, minimalism, education, historicity, precedents

74 BAYA algorithm: characterization of the behaviour of braided structural shells
Quentin Chef, Marc Leyral and Marc Hymans
Keywords: wicker, shells, braiding, weaving, dynamic relaxation, grasshopper, optimization

571 Free explorations of the polar zonohedron domes
Leila Cristina Meneghetti, Fernando Simões, Estevão de Carvalho Laurito, Ruy Marcelo Oliveira Pauletti and Arthur Hunold Lara, Marc Leyral and Marc Hymans
Keywords: polar zonohedron, domes, gridshells, architectural geometry, Zonotopia

178 Integrating Environmental Considerations in Structural Engineering: Challenges, Opportunities, and Solutions
Sandie Kate Fenton, Lars De Laet and Klaas De Rycke
Keywords: Structural engineering, Life Cycle Analysis, Workflow, Tool development, Environmental engineering

Room E3 - WG 21 Advanced Manufacturing and Materials

Moderator: **Alberto Pugnale**

232	Coupled Miura-ori Structures Along Space Curves **Sora Moriyama,** Chuang Kuo-Chih and Tomohiro Tachi	*Keywords:* origami, Miura-ori, morphology, curvature programming, space structure
424	Reimagining Design for a Light Environmental Impact: The Paper Composition Pavilion Maren Zywietz, Karsten Schlesier,**Vincent Stiehle,** Vincent Krauss, Anna Plate, Henrik Stamm, Anika Wallbrecher, Ahmad Bawar And Sara Mohammadi	*Keywords:* research pavilion, circular economy, lightweight structures, sustainability, alternative building materials
566	Innovative Reclamation and Design: A Lightweight Structure from Reclaimed Golf Clubs Javier Cardenas, Carson Maggard, **Mason Moya**, Micah Regier, Tahmures Ghiyasi and Ali Ghazvinian	*Keywords:* resource-driven design, lightweight structure, structural optimization, form-finding
323	Modularizing Schwarz D-Surface structures with hypar based timber shell components **Markus Hudert,** Laszlo Mangliar, Victor Sardenberg, Amirhossein Heidari and Aryan Rad	*Keywords:* Timber and bio-based structures, Modular timber structures, Circular construction, Schwarz D-Surface, Hyperbolic paraboloids, Reconfigurable structures, Upcycling scrap wood, Conceptual design, Digital modelling and fabrication
318	FloaTree: a system for making artificial habitat structures informed by AI-generated visual abstractions of large old trees **Alberto Pugnale,** Sofia Colabella, Michael Mack, Gabriele Mirra, Michael Minghi Park, Jack Halls, Alexander Holland, Stanislav Roudavsk	*Keywords:* reciprocal structure, artificial tree-like structure, design for disassembly, more-than-human design

Room E4:- WG 15 Structural Morphology

Moderator: **Günther Filz**

50	Defining Geometries for Reusable Plate Systems **Ellen Leemans,** Niels De Temmerman and Lars De Laet	*Keywords:* Reusable building systems, Modularity, Event structures
626	Infrathin – Nine Structures of Extreme Slenderness **Guy Nordenson,** Gina Morrow, Erich Oswald, Brett Schneider and Xiaoxiao Wu	*Keywords:* slender structures, material efficiency, art of structural engineering, structural elegance
203	Rethinking Naturally Shaped flexible grid structures combining bending and twisting Fereshteh Khojastehmehr and **Günther H. Filz**	*Keywords:* Spatial structures, elastic gridshell, twist, geometrical pattern, Gaussian curvature, architectural geometry, structural morphology, multi-objective design, timber and bio-based spatial structures
83	Modular Lattice Bridges Inspired by Système Eiffel Henrique Martins and **Ashley Thrall**	*Keywords:* Lattice bridges, Modular bridges, redundancy, Triangular module stacking
200	On structural morphology of snow vaults Esko Järvenpää and **Antti Niemi**	*Keywords:* Snow vault structures, Constant stress vault, Weak material structure
236	Diatom-inspired Computational Design of Radial Framework Structures: The Case of Asterolampra **Stephanie Bachir**	*Keywords:* Diatoms, Patterns, Biomimetic Design, Lightweight Structures, Computational Design
449	From nest to bridge: Exploring avian construction techniques for innovative architectural solutions Dana Saez, **Raman Suliman**, Matías Lichtensztejn, Santiago Miret, Andrija Pranjic and Martin Trautz	*Keywords:* learning from nature, animal constructions, avian nest constructions, reciprocal frames, self-supported structures, stacking problem, structural morphology, self-supported scaffold, innovative architectural solutions
457	Muqarnas 2.0: Topological Design of Stackable Polyhedral Blocks for Reconfigurable Masonry Corbell-Squinch-Vault Structures **Anna Kaletkina**, Elnaz Ghafourian, Sabrina Pisano and Pirouz Nourian	*Keywords:* Structural Topology, Reconfigurable Structures, Mass Customisation, Muqarnas, Compression-Only Structures
204	Self-Aware Spatial Pattern Model: beyond shape, towards adaptive form **Mohammad Hassan Saleh Tabari** and Günther H Filz	*Keywords:* Pattern topology, Elastic Structures, Weaverbirds, Structural performance, Reinforcement learning, Decision-making, Creativity
102	A new configuration of Levy-type cable domes with load-relieving system **Cheng Ye**, Chao Yang and Yaozhi Luo	*Keywords:* Cable Dome, Load-Relieving System, Finite Particle Method, Structural Performance Improvement

Room E7:- WG 6 Tension and Membrane Structures

Moderator: **Marijke Mollaert**

433 Form-finding of cable-strut structures with sliding cables
Yu Xue, Yaozhi Luo and Wei Wang
Keywords: cable-strut structures, sliding cable, form-finding

100 Topology Optimization of Active Tensegrity Structures
Yafeng Wang, Xian Xu and Yaozhi Luo
Keywords: topology optimization, active tensegrity structure, mixed integer programming, low-carbon buildings

141 Generation Of A Structural Shape And System Through The Integration Of Tensegric Elements Into A Double-Layered Frame Structure
Nobuko Ishikuri, Makoto Yamakawa, Hiroshi Amano, Kazuma Goto and Kentaro Nagasaka
Keywords: tensegrity, tensegric, space frame structures, double-layered frame, design, stiffness

289 Form-finding and structural modeling of membrane-tensegrity composite structures with proposal for highly feasible model
Yohei Nagano and Takuo Nagai
Keywords: tensegrity, membrane structures, form-finding, stiffness evaluation, physical model experiment

324 Impact resistance of six-strut tensegrity
Zhaojun Liu, Xian Xu, Meijia Wang and Ruhe Mei
Keywords: six-strut tensegrity, impact resistance, finite element, dynamic analysis, parametric study

623 Lightweight Design of Tensegrity V-Expander Structures
Muhao Chen, Aguinaldo Fraddosio, Andrea Micheletti, **Gaetano Pavone** and Mario Daniele Piccioni
Keywords: Minimal mass design, Nonlinear optimization, Clustered tensegrity structure, V-Expander tensegrity

Room E8 – SS13nG Next Generation Parametric Design (WG13)

Moderator: **Robert Otani**

253 Structural Embodiment – Unified Workflow and Toolkit for Form-finding, Solid Geometry Generation and Visualisation via Deep Learning Methods
Tao Sun, Pierluigi D'Acunto and Frank Petzold
Keywords: Deep learning, Structural Design, Graphic Statics, Parametric design, Form-finding, Materialisation, Visualisation, Stable Diffusion, Digital Design Tool

299 A Graph-Based Grammar for Structural Design Using Deep Reinforcement Learning
Lazlo Bleker, Kam-Ming Mark Tam and Pierluigi D'Acunto
Keywords: Structural Design, Form-Finding, Machine Learning, Reinforcement Learning, Graph Neural Networks

359 Structural Design and Optioneering of Form and Function Leveraging Generative Deep Learning
Seyedomid Sajedi, Aloy H. Kemp and **Robert. K. Otani**
Keywords: Generative deep learning, Finite-element analysis, AI-assisted optioneering, Steel arch design

33 Structural analysis of concrete shells using deep learning methods
Maxime Pollet, Paul Shepherd, Will Hawkins and Eduardo Costa
Keywords: Concrete, Shells, Structural analysis, Machine Learning, Deep Learning, Feed-Forward Neural Network, Convolutional Neural Network, Graph Neural Network

478 Fast Prediction of Stress Distribution A GNN-based surrogate model for unstructured mesh FEA
Jiaqian Wu, Chaoyu Du, Benjamin Dillenburger and Michael Anton Kraus Paul Shepherd, Will Hawkins and Eduardo Costa
Keywords: stress prediction, GNN, surrogate model, unstructured mesh, FEA, machine learning

590 AI-guided generation of reticular structures by integrating reinforcement learning with shape grammars
Vishnukumar Rajasekar, Juney Lee, Aysenur Gencsoy, Klaas De Rycke, Pierpaolo Ruttico
Keywords: reinforcement learning, shape grammar, computational design

513 Human-in-the-Loop Structural Optimization: A Paradigm Shift in Structural and Architectural Design
Jonathan Melchiorre, Amedeo Manuello Bertetto, Giuseppe Carlo Marano and Sigrid Adriaenssens
Keywords: Artificial Intelligence, Structural Optimization, Creative Vision, Architectural Design, Human-AI Integration

Room E9 – SS20 Combining high-end digital and low-tech teaching methods for shell and spatial structures within the planetary boundaries

Moderator: **Maxence Grangeot**

284	Caña Viva Pavilion, a Sustainable Low + High Tech organic proposal **Ronan Bolaños L.,** Marcos Ontiveros H., Rodrigo Shiordia L. and Lorelí Ortiz T.	*Keywords:* Parametric Design, Digital Fabrication, Natural Building Techniques, Sustainability, Natural fibers
179	Ultra-thin-layered 3D-printed hollow core sections for concrete casting Mohsen Vatandoost, Wesley McGee and **Peter von Buelow**	*Keywords:* additive manufacturing, hollow-core section, thin-layer formwork, 3D-printed mold, automation in construction, robotic fabrication, lost formwork, stay-in-place formwork, eggshell formwork, drop-pan formwork
352	AR-enabled circular construction of a computationally designed reclaimed wood shell structure **Daniel Fischer**, Tamara Haußer, Vincent Witt, Fanny Kranz, Riccardo La Magna and Moritz Dörstelmann	*Keywords:* AR, wood nails, circular construction, computational design, shell structure, recycle, reclaim, reuse, timber
170	Straw, from modelling to full scale Aurore Champagne and **Klaas De Rycke**	*Keywords:* straw, artificial intelligence, optimization, geometry
354	An Investigation into Machine Learning Matchmaking for Reused Rubble Concrete Masonry Units (RR-CMU) Daniel Marshall and **Maxence Grangeot**	*Keywords:* Machine Learning, Reuse, Circularity, Concrete, Embodied Carbon, Matching Algorithms, Computational Design