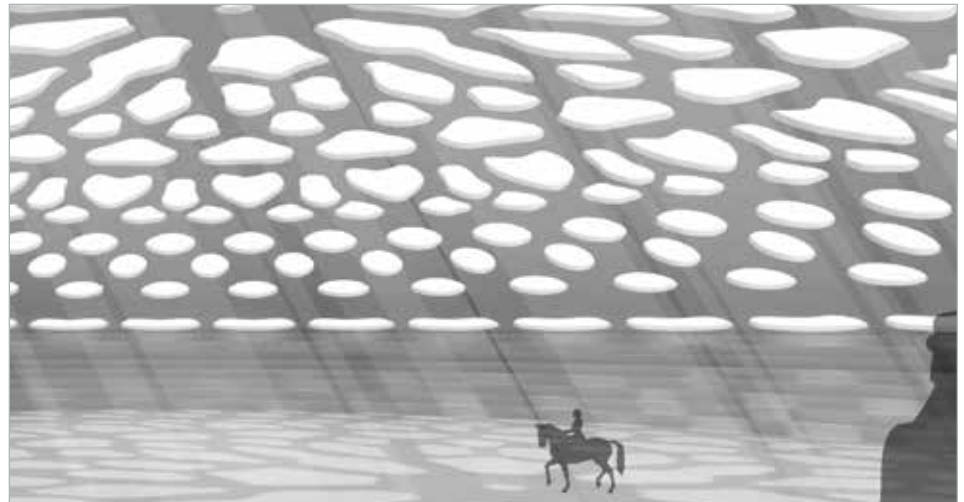
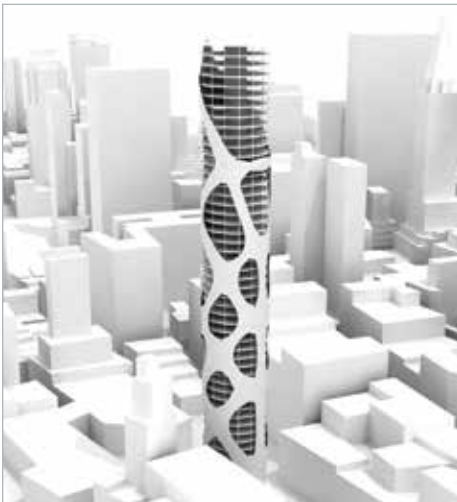


Biberach University of Applied Science, Institute for Architecture and Urban Development (IAS)



Key Highlights

Industry

Architecture Engineering Construction (AEC)

Challenge

Create modern, functional, stiff, and light architectural designs.

Altair Solution

Use Altair's OptiStruct to create feasible designs.

Benefits

- Lighter and stiffer buildings
- Material reduction and cost savings
- Higher level collaboration between engineers and architects
- Fewer design iterations
- Final design faithful to the initial concept

Customer Profile

Biberach University of Applied Sciences is a technical university focused on providing students with a practical education right from the start. Semester-long internships are compulsory, and students draw from practical experience to work on class projects and complete their bachelor's or master's thesis. The university cultivates close ties to the business world, connecting its research institutes with like-minded companies. Offering programs in architecture, urban planning, civil engineering, business, energy efficiency, biotechnology, real estate, project management, and construction, the university provides an interdisciplinary platform for learning and teaching.

The university's Institute for Architecture and Urban Development was founded in 2010 to foster research spanning a wide range of topics in the field of architecture. The institute's only civil engineer, Professor Lochner, teaches courses on architectural design with a special focus on engineering concepts. To introduce students to cutting-edge design and engineering tools, she turns to Altair's OptiStruct.

Prof. Lochner became familiar with OptiStruct while completing her PhD, which explored whether or not redesigning historic structures using structural analysis solvers would lead to the same design as the original. Using OptiStruct, she redesigned the ceiling

Biberach University Success Story



“As a civil engineer who teaches at an architecture institute, I appreciate the growing merge of engineering and architectural design. With tools like OptiStruct, we can create beautiful designs that are also structurally efficient and buildable. OptiStruct facilitates designs that are modern, functional, and feasible.”

Prof. Dr. Irmgard Lochner-Aldinger

Biberach University of Applied Science, Institute for Architecture and Urban Development

of architect Carlo Cestelli Guidi and engineer Pier Luigi Nervi's *Gatti Wool Factory* (Rome, 1951), performing a number of optimizations with the same design space and load cases but different supports. This produced several structurally efficient designs for the ceiling (image 6), revealing that a design has more than one optimal solution.

OptiStruct in Architectural Design and Teaching

OptiStruct's topology optimization capability is based on the evolution of bones over millions of years into well-adapted forms. Take, for example, the side-by-side evolution of the crab and the diatom: the crab's claws

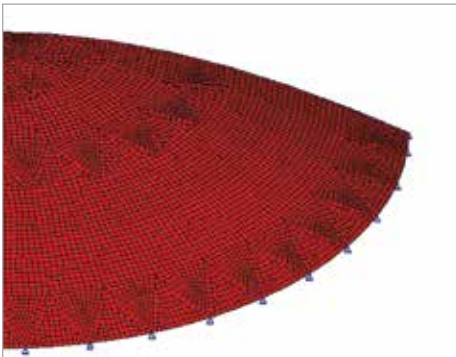
have strengthened to more easily attack its prey, while the diatom's shell has hardened for better protection from its predator (image 7).

Time-tested organic structures such as these can be a great a source of inspiration for structurally efficient architectural designs. Following this idea of biomimicry, in a recent course Prof. Lochner asked her students to create building designs in OptiStruct based on two biological structures: the diatom and the cactus.

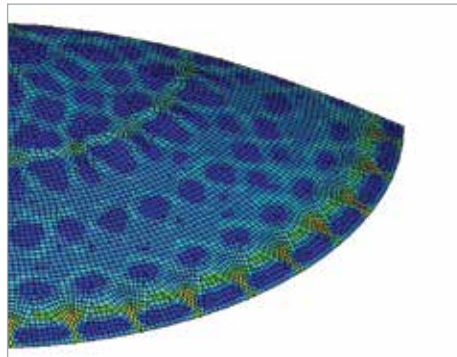
Taking inspiration from the diatom's shell, students designed a load-bearing dome structure. After modeling one quarter of the structure, they applied a distributed

load (images 1, 2, 3) and ran optimizations to maximize stiffness (thereby minimizing deflection) and minimize material. The result was an organic, lattice-like dome structure.

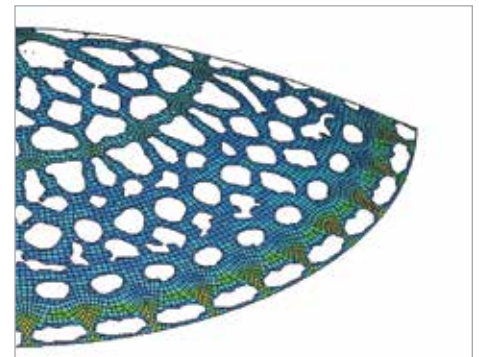
Emulating a columniform cactus, the students designed a skyscraper. They ran optimizations by applying wind loads, setting boundary conditions to maximize stiffness, and defining the maximum amount of material to be used. The result was a slightly asymmetrical tubular structure (images 4, 5) that is stiff enough to withstand wind forces from all directions. The hollow core provides ample space for elevators, stairs, a disposal system, and other features.



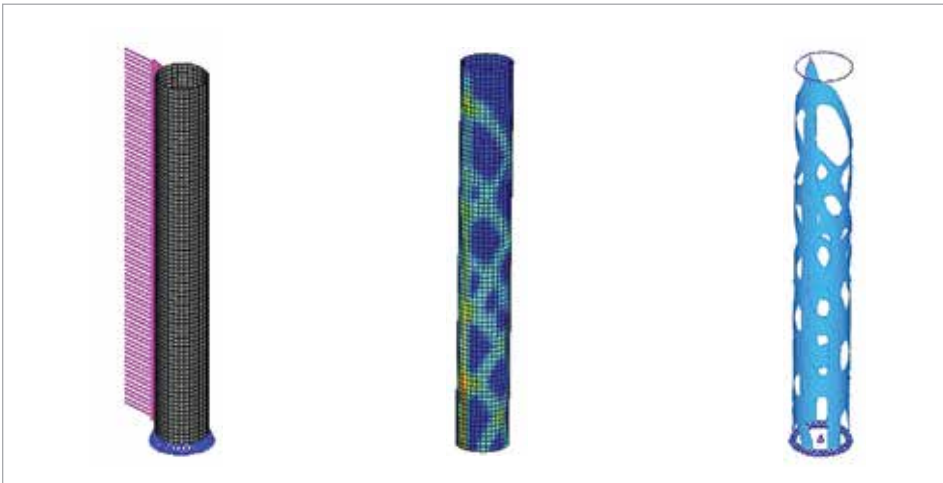
1. Model of one quarter of the shell structure



2. Optimized design proposed by OptiStruct



3. Optimized design proposed by OptiStruct



4. Using OptiStruct, dominant wind loads were applied to the tubular skyscraper structure (left) to produce an optimized design (right).



5. The skeleton of a columniform cactus (left) inspired the tubular design of a skyscraper (right).

Optimization Influences Design

“Using an optimization tool such as OptiStruct has definitely influenced the way I design and construct. Obviously design is always a question of taste—some architects prefer square buildings, others organic structures. I prefer designs that follow examples from nature. The great thing about OptiStruct is you don’t end up with just any type of organic structure, but one based on engineering fundamentals. Your design has an extraordinarily intriguing form and it can actually be built,” says Prof. Lochner.

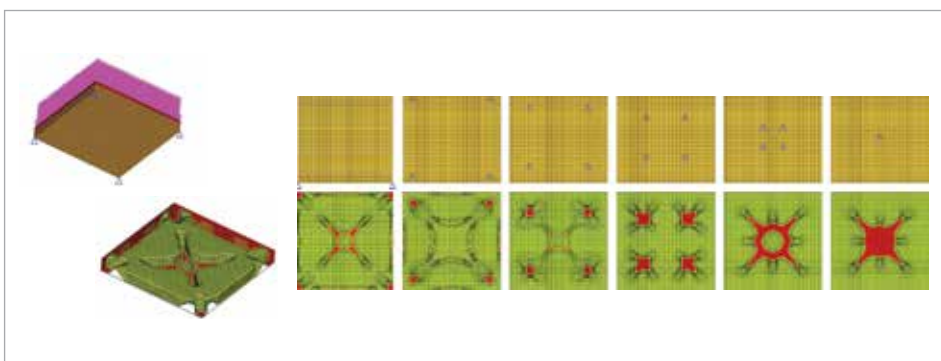
Thanks to a growing trend towards organic structures, the gap between architecture and engineering is becoming smaller.

By reducing the number of design iterations between engineers and architects, optimization-driven design fosters synergy between the two disciplines. This results in a final design that is more faithful to the initial concept and a simpler construction process. In addition, lighter buildings translate into reduced material consumption and costs.

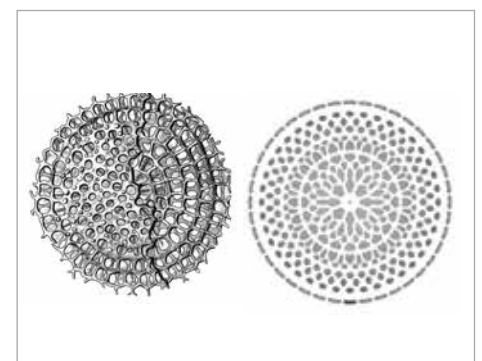
What's Next?

Next semester Prof. Lochner will conduct research as a visiting scholar at Princeton University. She plans to explore the possibilities of solidThinking Inspire, a concept design tool based on OptiStruct technology. She concludes, “Inspire’s simple

user interface may be an even better fit for architecture students. Altair’s software supports our efforts to teach engineering concepts to architects and to develop more extraordinary designs. I really like working with Altair—their support is great and I enjoy their networking events, such as the Altair Technology Conference. I’m sure that we’ll continue to use their solutions in future courses and research projects.”



6. Systematic variation of the ribbed slab structural system produced parametric patterns (left) that led to a number of design proposals (right).



7. Ernst Haeckel's illustration of a diatom (left) inspired the design of a gridshell structure (right).

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From computer-aided engineering to high performance computing, from industrial design to cloud analytics, for the past 30 years Altair has been leading the charge to advance the frontiers of knowledge, delivering innovation to more than 5,000 corporate clients representing the automotive, aerospace, government, and defense industries and a growing client presence in the electronics, architecture engineering and construction, and energy markets.

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