THROUGH THE ROOF

Jan Knippers of engineering firm Knippers Helbig talks about the importance of breaking out of model thinking.

Text Terri Peters

Jan Knippers (right) and Thorsten Helbig. Photo Klemens Ortmeyer

On a cold Copenhagen morning, I meet engineer Jan Knippers outside a closed café in the district of Vesterbro. It's Saturday, and the cafés in this part of town don't open until ten, but he's agreed to fit me into his schedule between a lecture at the architecture school and his flight back to Stuttgart. This is a man whose time is in demand. He teaches at the Institute for Building Structures and Structural Design (ITKE) in Stuttgart, gives lectures in cities around Europe, and works on projects at Knippers Helbig, a firm with offices in Stuttgart and New York City. He assures me, however, that finding an hour for a quick meeting is always a possibility. We spot a place to sit and talk about the impact of digital design on the engineering profession, the best ways to create structural failures, and new structural-design research involving biomimicry.

A building project often pits architects against engineers. Why do you think this happens?
Jan Knippers***:*** There are two basic things that architects should know about engineers. The first is that all engineers – not only structural engineers, but also mechanical and aerospace engineers – are trained in model thinking. That's why every book you find on engineering, even my own, contains a table with a pool of options for building structures that are subdivided according to the complexities of geometry, basic load-bearing systems and so on. What engineers do is to look at these tables and choose options that meet the challenges of, and are appropriate to, the problem they want to solve. This pool of options is influenced by history and experience, but it always follows a given model, which means that on a conceptual level the degree of innovation is not very high. The second thing is that for an engineer, a good design means optimization of efficiency. Since my first day of university, I've been told that a good structure is one that uses the least amount of material and is as light as possible. We learn that these are the only criteria that matter. And it's not always true.

So a light structure is not always the best solution?
No, not always. If you use timber for a bridge, for example, it might be good to use as much timber as you can, as long as it comes from renewable resources. Timber stores carbon dioxide, so it's possible to build a heavy timber bridge that meets the design challenges. We used this strategy for the Margaretengürtel Bridge in Vienna, a project we did with Knight Architects. It's our first winning bridge design. Our office is ten years old, and over the years we've entered many bridge competitions but were never successful. It could be because all engineers are doing exactly the same thing: proposing very light, transparent structures. After ten years of failing to win bridge competitions, we reconsidered the 'light and transparent' design goal. The bridge in Vienna is in a very prominent place at the heart of the city. It will be finished in late 2013. It is a pedestrian and cycle bridge with a free-form frame made of laminated timber girders. The design achieves a positive CO_2 balance and uses local materials.

Your lecture at the Digital Crafting Symposium yesterday was about the potential of new processes of design and fabrication. How have these processes changed the way you practise engineering?
This new digital chain of design and fabrication is not only about new tools that allow for fancy geometries, but also about the whole conception of what engineering is and what engineers can do. The relationships involved have the potential to be completely redefined. New design processes are causing such a fundamental shift that new roles have not yet been established. Engineers now have an opportunity to break out of model thinking, to go beyond optimization, to follow paths not yet taken. It allows us to go beyond the design of the detail and focus, too, on designing the *processes* of design and manufacturing – and on designing a relevant tool.

'There are two basic things that architects should know about engineers'

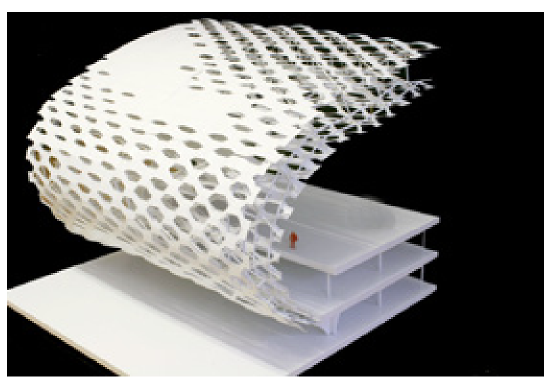
You and Thorsten Helbig established Knippers Helbig in 2001. How did you begin working together?
We both worked for engineer Jörg Schlaich. After a few years there, we decided to found our own office. We share responsibilities. For example, Thorsten headed the Bao'an Airport project in Shenzhen, and I took charge of the Shanghai Expo project. But we have a team of about 30 people that work together on all projects; no one person does it alone. The majority of us are engineers, but we also have a physicist, a mathematician, two researchers and several architects.

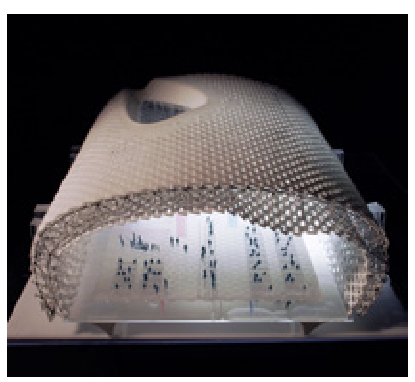
What was your first big project?
The Peek & Cloppenburg department store in Cologne [2005] was one of the very rare projects that included an engineering competition. The architect, Renzo Piano, designed a five-storey building. The challenge for us was how to design a very light, transparent timber façade to be supported by the building's concrete frame. We used vertically arranged trusses with wooden members and horizontally ▷

Bao'an International Airport, Terminal 3
Massimiliano and Doriana Fuksas
Shenzhen / China
2012 (under construction)

Studio Fuksas designed an extension for the Shenzhen airport, and Knippers Helbig took responsibility for the façade. The building has a 200,000-m^2 double-layered façade and roof construction with spans up to 80 m. Knippers Helbig developed a parametric design tool for the façade, which consists of 60,000 panels attached to a free-form shell with windows of different sizes. Besides providing specific dimensional data for each panel and each design iteration – and executing the definitive design – the engineers came up with a geometrical solution for the building's 450,000-member frame.
Photos and rendering Studio Fuksas


Erecting the main structure on site.

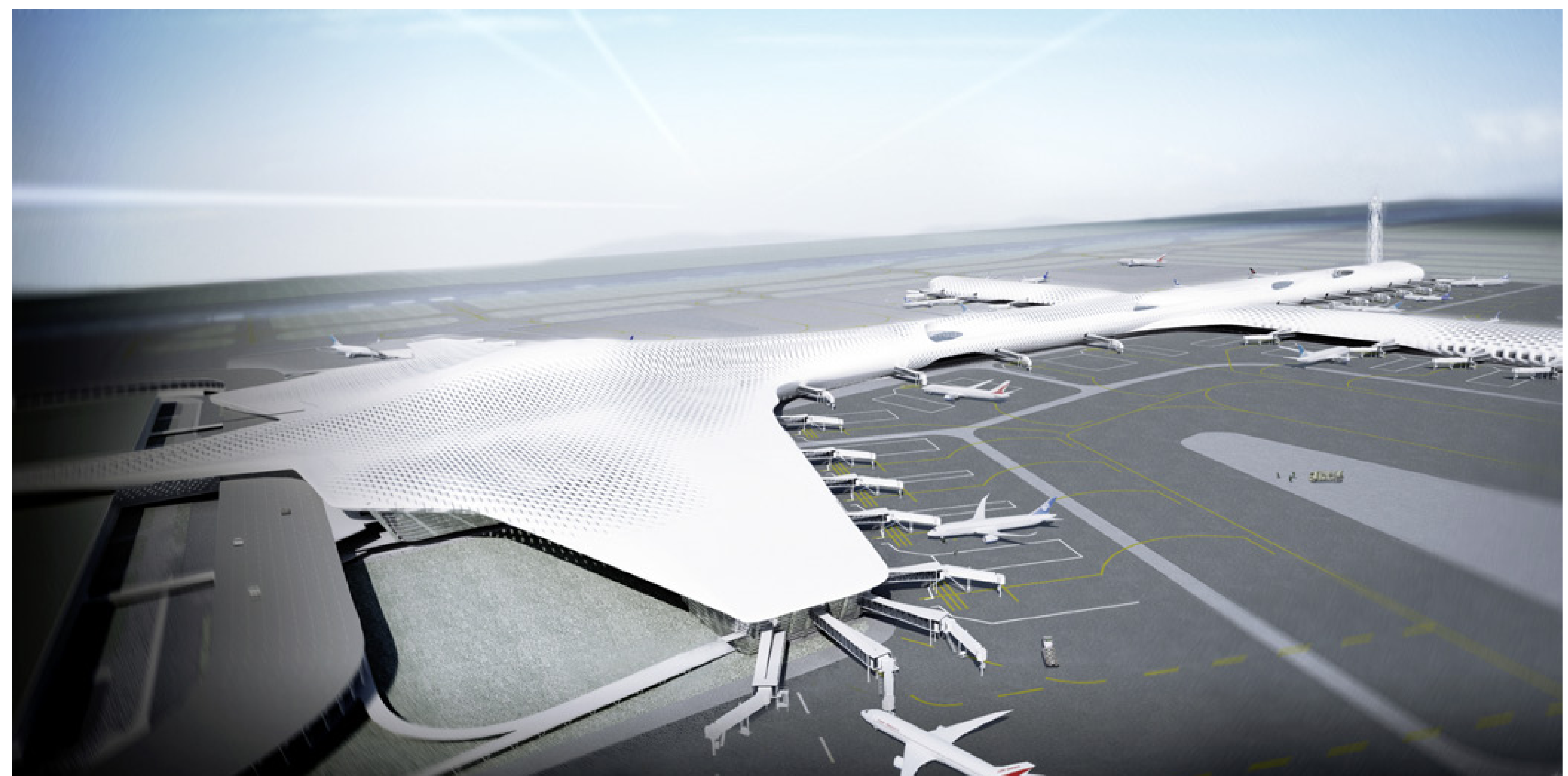




The building has a steel skeleton and a concrete substructure. The skin that envelops the structure has a honeycomb motif on both the inside and the outside.

'It's often better to work with lesser-known architects'

Mock-up.



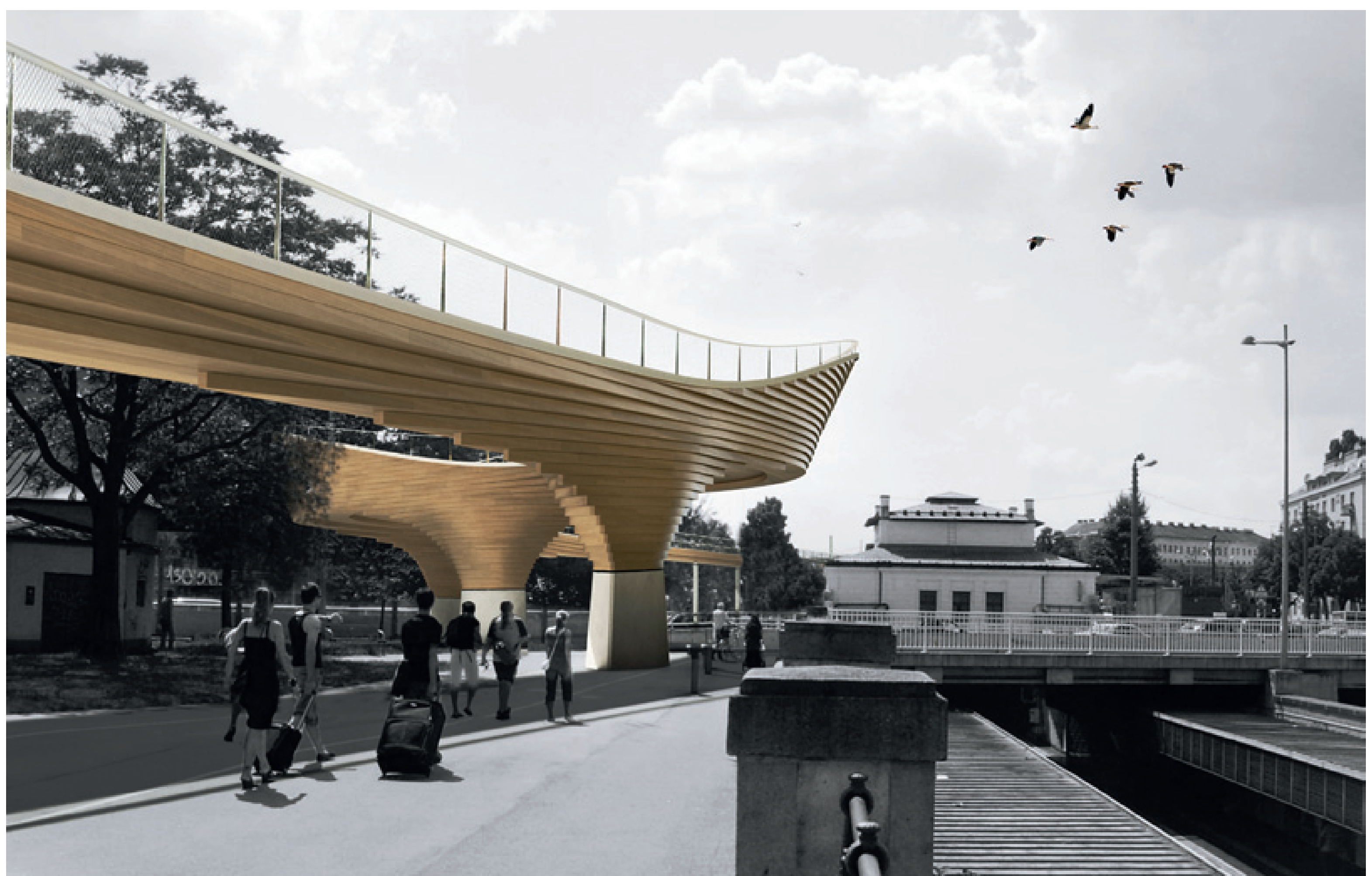
◁ running façade tubes attached to the shell with diagonally spanned cables. The façade has no support from the ground; it's attached to the structure at two points. We were faced with a large span and a large deformation of the concrete slabs, so the main issue was how to make the façade correspond to the light, delicate shell. Timber lamellas may look very simple, but from an engineering perspective, it's difficult to handle wood in that way. Wood contains fibres, which can mean creep, shrinkage or expansion. We worked a lot with mock-ups, considered various methods of attachment, and subjected the different systems to load-bearing tests in the university laboratory.

You are currently working on your largest project to date: a 1.5-km-long façade for the Bao'an Airport in Shenzhen, China, which was designed by Studio Fuksas. When the airport opens in 2014, it will serve 40 million passengers annually. What were your major engineering challenges?
The airport will have a shimmering, folded-aluminium and glass façade. The geometry is extremely complex. It has a free-form steel skeleton and a concrete substructure with a triple-layer structural system to support the internal 80-m-clear span. In the simplest of terms, we took flat sheet material and mapped it on a curved 3D surface. We needed many physical models to understand the complexity involved, and we had to keep certain factors in mind at all times, such as the visual inside-outside connection and solar gain. The two basic parameters for the skin were the size and the slope of the glass. We used 'low tech' digital tools that we developed ourselves. In terms of handling such a degree of complexity, there's no magic formula, just a lot of hard work.

'After ten years of failing to win bridge competitions, we reconsidered our design goal'

What else is currently in the works?
The Thematic Pavilion for Expo 2012 in Yeosu, South Korea. We developed a kinetic façade with Soma Architecture, a young design office in Vienna. They came to us with a rendering of their winning competition entry for the pavilion, which features a moving façade. Together, we figured out how it could work, how it should look and how it could be made. It was a lucky coincidence that our firm was working at the time on precisely the type of elastic deformation needed for the pavilion. We have two PhD students in the office, one who's concentrating on engineering aspects of elastic deformation and another who's categorizing different plant movements and how they can be transformed into architectural forms.

I was trained to avoid structural failure at all costs – and buckling, in particular – and here we are doing it. [He takes a piece of paper and twists it.] Highly complicated theories have been developed and calculations made to discover at what point buckling and deformation start to happen. We went in a completely different direction from that of conventional engineering and designed a buckling form, which we used as a moving lamella. The result is a €1 million research project based on what might appear to be a simple little mechanism – just one small component. But it's really changed our perspective on architecture. Looking at natural forms and understanding new ways of creating function are what have emerged from this research. One of the major issues in biomimicry is scale. How can material or performance be scaled for application in building projects?



Have you been to the site in Yeosu?
No. Once we had finished the design stage and handed over our work to the Korean contractors, we heard . . . nothing. Later we got an email with a camera-phone video of 1:1 prototype testing on site; that was one of the happiest moments of last year. They're really building the pavilion! It's a bit strange when you're not there to learn during the execution of your design, but every project has a different collaborative process.

In 2009 you opened an office in New York City. What projects are being developed there?
Our New York work includes a project in China with Grimshaw, a smaller project with Asymptote and a competition entry with Diller Scofidio + Renfro.

Those are some big names in architecture. How do you choose which architects to work with?
Engineers are often considered 'good' because they work with famous architects. We believe that sometimes it's even better to work with lesser-known architects and offices; we often have more options, more chances to explore ideas and to offer our own input. Take the Peek & Cloppenburg project, for instance, where the entire geometry of the project had been defined before we began. Even the design of the lamellas had been decided – not how to attach them, of course, but how they should look. Working with famous architects can be important for your portfolio, but you can be part of interesting engineering projects with all kinds of offices. ◁

knippershelbig.com

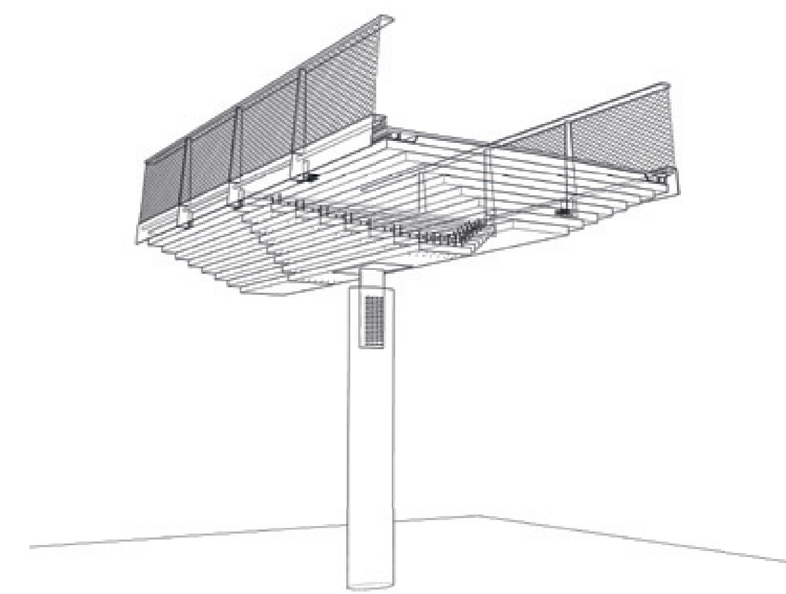
Pedestrian Bridge

Knippers Helbig,
in collaboration
with Knight Architects
Vienna / Austria
2013 (expected completion)

In collaboration with British firm Knight Architects, Knippers Helbig won a design competition – open to 37 teams composed of engineers and architects – for a footbridge in the area of the Margaretengürtel metro station in Vienna. The design, which includes a high-level walkway and a cycle path, links two previously separated city parks.
The project is a prime example of an integrated approach to energy conservation (grey energy) and efficient recycling, thanks to the systematic use of large quantities of locally available timber, which stores CO_2 and costs relatively little to process. The bridge, with its free-form frame of laminated timber girders, uses a fraction of the energy required for the construction of a concrete or steel bridge of the same size.

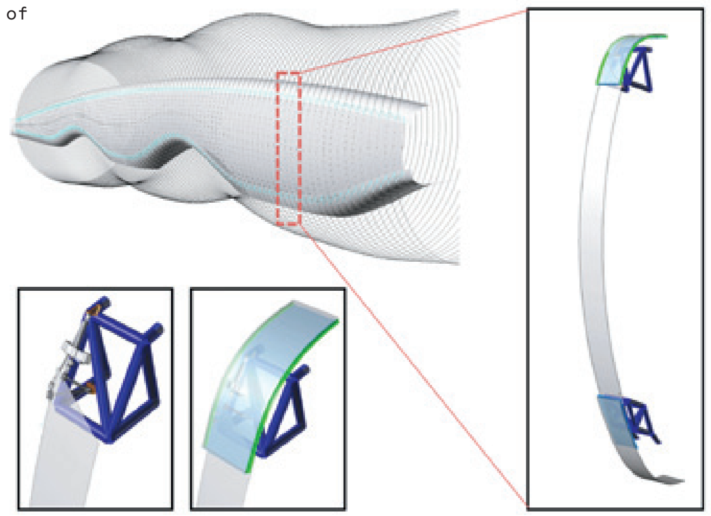
Renderings Knippers Helbig

A gradient of less than 4 per cent offers users a gentle climb.



Site plan.

Louvres are made from fibre-reinforced polymer, a strong, flexible plastic. Each louvre has one thinner and one thicker edge and is equipped with actuators, top and bottom. These devices allow the louvres to compress asymmetrically, creating outward and sideward deformation and giving an impression of flaring fish gills. After dark, LED lighting increases the effect of a living fish gliding through water.



Thematic Pavilion

Soma Architecture
Yeosu / South Korea
2012 (under construction)

Viennese architecture firm Soma won the competition for a pavilion to feature at South Korea's Expo 2012. The firm asked Knippers Helbig to engineer the pavilion's kinetic façade.
The building has two main façades. The waterfront façade refers to pebbles, and the kinetic façade, which boasts the main entrance and faces the event grounds, symbolizes the gills of a fish. More than 100 individually moving louvres can be programmed to respond to the position of the sun and the intensity of sunlight. The façade can also 'perform' to a choreographed program and react to individual events.

Renderings Soma Architecture

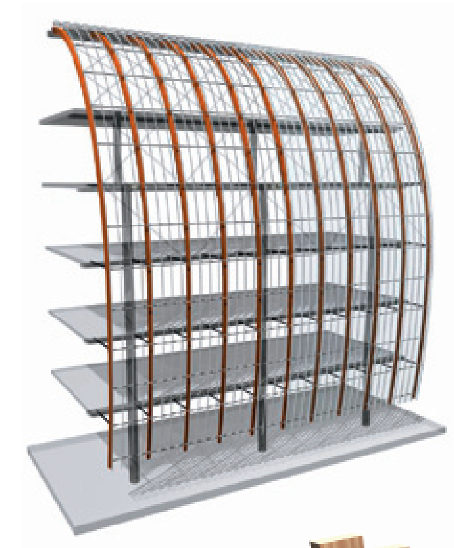


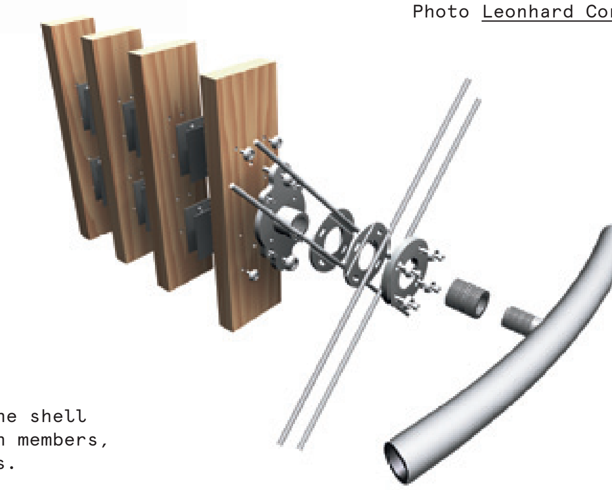
Photo Leonhard Coreth

Peek & Cloppenburg

Renzo Piano Building Workshop
Cologne / Germany
2005

A glazed dome tops Renzo Piano's concrete-framed Peek & Cloppenburg department store. Knippers Helbig designed the façade, whose imbricated skin consists of 6,800 individual glass panes. Knippers Helbig wrapped the frame of the five-storey department store in a free-form shell structure. Vertically arranged timber-lamella trusses and horizontally running façade tubes are attached to the shell with diagonally spanned cables. The lamellas are graded from floor to floor according to the strain. The Siberian-larch trusses were completely prefabricated. The engineers attached the shell structure to the concrete frame at only a few rigid points, enabling an almost complete isolation of distortion forces. On the fourth floor, the façade shell is attached by means of consoles.

Renderings Knippers Helbig



Detail of diagonally spanned cables.

An interior view of the shell structure shows wooden members, cables and attachments.
Photo Michel Denancé