Form follows material

The Egyptian, Hanaa Dahy, wants to incorporate intelligent materials into architecture

She followed the usual career path of an architect until an event in her home country opened her eyes, from which point on Hanaa Dahy has been interested in sustainable building and has developed a straw composite material which has received several awards. As junior professor and head of the Department of Biomaterials and Material Cycles in Architecture (BioMat) at the University of Stuttgart, she provides students of architecture with the wherewithal to develop sustainable and intelligent building components.

Some of her students have presented sketches of their building concepts on posters in the entrance area of Kollegiengebäude I on the Stadtmitte campus, miniature three-dimensional models of which are placed on small stands in front of the walls, delicately constructed of cardboard, plywood, polystyrene or plastic foil. Dahy's office is four floors above in the Institute of Building Structures and Structural Design (ITKE). The junior professor is calling for a rethink of building planning, and is starting with the students.

"Architects usually produce beautiful designs during their university studies, but they don't necessarily know how the building could be built," says Dahy. For the architect, however, the material and its properties are at the beginning of every concept. Is there a material for the desired purpose? How can the desired material be adapted or created? The 38-year-old can't understand why even in hot countries houses are built in the style of international architecture with large glass fronts that have to be cooled down with air conditioning systems. "The local architecture, which matches the local resources and climate, is almost non-existent," Dahy complains.

Instead of using only proven materials, Dahy gives students the opportunity to develop new materials and experiment with smart systems such as solar cells and sensors. "This enables innovative systems that are truly sustainable and can reduce the enormous energy consumption," Dahy explains. In the "Material Matter Lab", which she set up at the Institute, the prospective architects immerse themselves in materials science, learn the basics of electrical engineering and learn how to program.

Materials inspire design

Among the design models the students subsequently felt inspired to create a façade made of pyramid-shaped elements covered in a light diffusing textile coating, which creates special lighting effects at night. The energy for the LEDs mounted on the back comes from solar cells cleverly integrated into the façade elements. Another of the resulting designs includes undulating timbers that can be moved by electromagnets enabling it to be adapted to different loads whilst simultaneously saving material. This could be used, for example, in chairs or bridges.

Another student developed an intelligent wall that changes color when a person approaches it. "Approaching a wall doesn't normally make you happy," say Dahy, "but this wall interacts with you." There is this trend in architecture, she goes on to say, to also create entertainment spaces: so this wall could become a magnet for visitors to museums or meeting places. In recognition of her teaching concept the Baden-Württemberg Foundation awarded her a senior fellowship for innovations in university teaching in 2016. Coincidentally, this grant also marked the beginning of her junior professorship at the ITKE.

Recently, Dahy's group has also been working on soft, supple robots for the smart building of the future, primarily on the materials needed for their construction. Unlike solid metal robots, these ones can change shape like amoebae and will in future be able to detect damage in the remotest corners of a building in good time to preserve the building for as long as possible. Soft Robotics could also help to anchor mobile, self-erecting wall elements to divide sports halls or other large rooms as required. Jan Petrs, a member of Dahy's staff, is working on robots that would crawl to where they were needed via a pipe system. "Motors or electrical components can make the building extremely expensive," says the architect which, she goes on to say, is what gave rise to the concept of such shared mechatronic components.

Photo: University of Stuttgart/M. Regenscheit;

"The beaches were gone"

Dahy remembers the moment about 15 years ago when she began to take an interest in sustainable building. As an artistically gifted child who had already won many painting competitions, she was the only one of five siblings to follow in the footsteps of her mother, a professor of architecture. During her architectural studies in Cairo, she founded her own architectural office and designed classical buildings. Her first project was two hospitals. But then one day, for the first time in five years, she revisited the beach of her childhood in Alexandria: "The beaches where I used to play were just gone," says Dahy. The water level had risen in a very short time and had flooded the beaches. The shock she felt about the consequences of climate change jolted her out of her slumber, says Dahy. The most obvious countermeasure she could take as an architect was the use of resource-saving materials in construction.

"In Egypt, there are individual researchers and non-governmental organizations dealing with the topic of sustainability and great young architects who take the local climate into account in their designs." Dahy reports: "But, unlike in Germany, there are no statutory regulations that oblige building owners to build energy-efficiently, especially in state buildings." The architect came to Stuttgart in 2009 along with her family and a scholarship from the Egyptian government to begin her doctoral thesis. "One important reason was the great collaboration between industry and research that exists in Stuttgart," said Dahy.

The University of Stuttgart, where many of her Egyptian professors had already completed their doctorates, became a second home to her. Because composite materials are already a major research topic at ITKE, Dahy concentrated on alternatives from renewable raw materials. She has developed flexible and recyclable fiberboards from straw, which is generated as waste during the grain har-

vest, and bioplastics. Whether it's designer furniture, curved partition walls or sandwich elements for thermal insulation, the potential applications are innumerable. The prizes Dahy won for the concept are lined up along the windowsill of her office. Some material samples at the far end of the large table in her office testify to the variety of forms this novel, now patented, composite can take.

A test for new materials: a research pavilion

From sustainable materials, it was then only the next logical step towards future-oriented architecture to also use components that react intelligently to their environment. In the summer of 2018, Dahy's flexible panels, which she had developed during her doctoral thesis, were used in the construction the BioMat Department's first research pavilion right next to the two college buildings. Around 40 students had previously developed various design proposals over a period of two semesters. Other young architects then analyzed how the curved pavilion elements could be optimally equipped with flexible solar cells for power generation, and how damage-detecting robots could be integrated into the pavilion.

"There is a huge movement towards digitization and smartness in all areas and Germany has always been strong in this field and is one of the leading nations in their development, especially within Europe," Dahy states. She is currently summarizing her experience with bio-based composite materials and ideas for sustainable building in a technical reference book. She would also like to push ahead with the market launch of her product, but, due to her research and teaching commitments and the establishment of the new research group, has simply not had the time as yet even if she were to turn night into day, for example to answer questions from the Chinese Patent Office with a view to extending the patent for her straw-based composite material to China. When it comes to the cause, she's willing to work hard. Even when she had her second child at the halfway point of her doctoral thesis and her husband was working on his own doctoral thesis in Tübingen, she did not take any time off. "At certain times I wasn't so happy with my progress: things weren't moving fast enough for me, but in the end it went quite well," says Dahy and laughs. Her success has proved her right.

Helmine Braitmaier

Photo: University of Stuttgart/ITKE, BioMat

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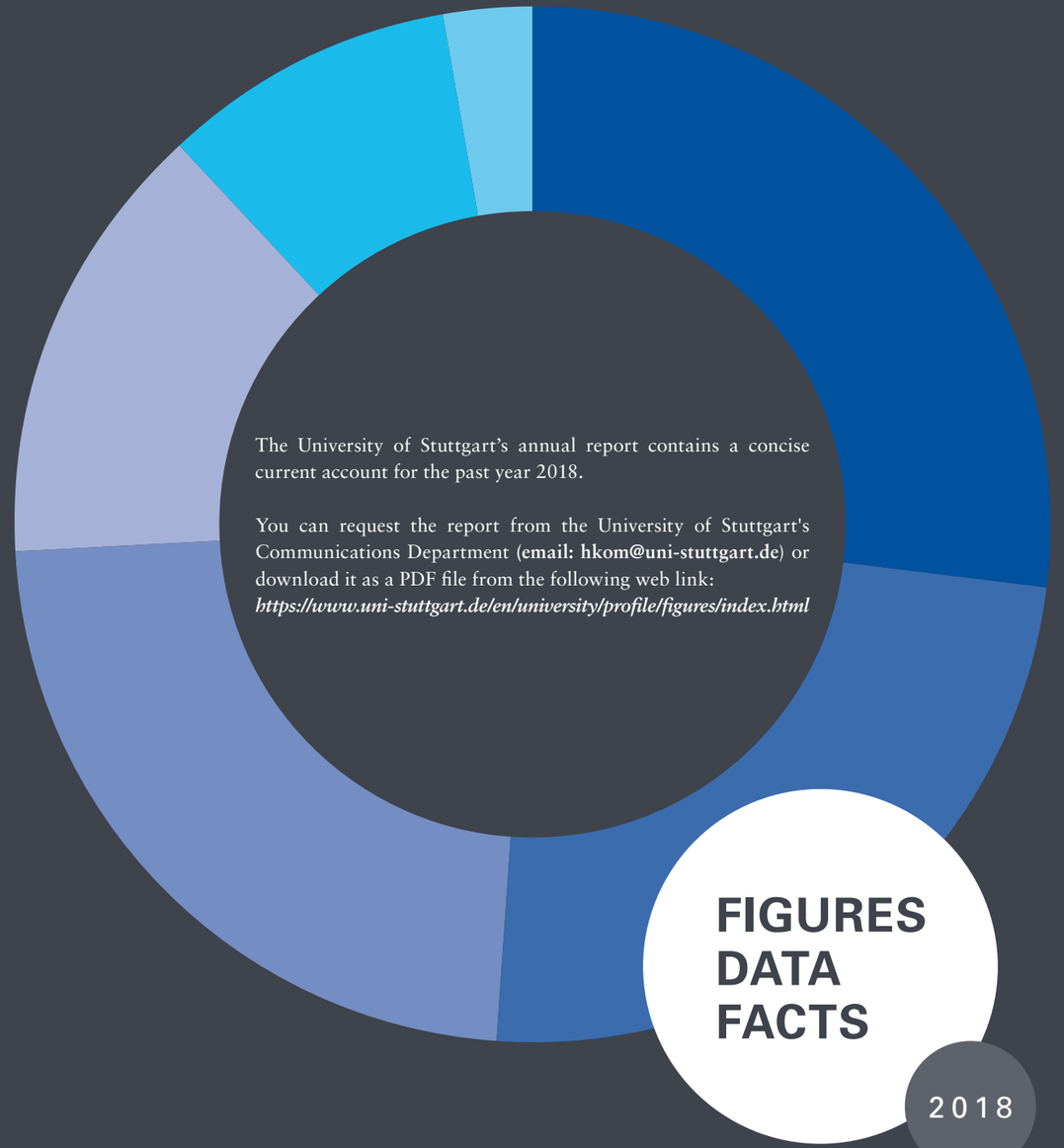

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