Revolutionising building sites

Digital technologies have already turned many areas of the economy inside out. Construction is the next sector set to undergo a change: more efficient processes, new materials and more varied houses are the objective.

INTERVIEW
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PICTURE CREDITS
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Mr Kohler, the website of the new National Centre of Competence in Research (NCCR) Digital Fabrication states the following: "Digital fabrication promises to revolutionise architecture." Does architecture need a revolution?

MATTHIAS KOHLER – That is less of an objective than an observation: the construction process is still highly conventional. Other sectors of the economy have been profoundly transformed by digital technologies. This raises the question of whether architecture and its downstream construction processes are also set for a change. The NCCR Digital Fabrication addresses this question: what is the added value if components are fully assembled by machines? What conditions need to be fulfilled so that people can work together with robots on building sites? And what effect will this have on drafting, planning and the construction culture?

Yet it must be noted that houses were built by robots in Japan some time ago. Are you reinventing the wheel?

KOHLER – It's true that some initial steps towards automation on building sites were already taken in Japan in the 1990s. There was a boom, but it collapsed suddenly for economic reasons. The idea at the time was to bring serial mass production from factories to building sites. It worked, but this technocratic approach resulted in limits on the architecture and bland buildings. In today's construction culture, a fitting, "tailor-made" solution for each situation is the objective. The quality of our living environments relies on this. When we take our robots to the building site today, our motivation is quite a different one: we are trying to establish how the processes can be ›

> "Automatic, tailor-made construction is the novelty."
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> MATTHIAS KOHLER

MATTHIAS KOHLER is Professor for Architecture and Digital Fabrication at the Architecture Department of ETH Zurich. In 2005 he established the world's first robot laboratory for non-standardised fabrication processes in architecture with Fabio Gramazio and thereby opened up an entirely new field of research.

BALZ HALTER is the owner and chairman of the board of directors of Halter Unternehmungen, which are active in the development, construction and operation of real estate property. He is an ETH graduate civil engineer and lawyer.

JONAS BUCHLI is Professor for Agile Robotics at ETH Zurich. His research focuses on model-based approaches to controlling robotic locomotion and understanding human locomotion as well as on machine learning and on dynamic service and field robots.

rationalised, but continue to allow tailor-made production at the same time. That's the actual novelty: every machine-made component can look different, even the individual production steps can be customised to a certain degree. That's what we're doing with our robots, for instance: depending on the task, the same robot uses different tools to assemble, process or shape something. This approach results in rational production already for relatively small lot sizes.

Mr Halter, is there actually any demand from developers for individualisation?

BALZ HALTER – Developers certainly want a more individualised appearance for their buildings. This is also having an impact on architecture: new shapes and materials are being sought. In the construction industry, we abandoned the mass production mentioned earlier because we noticed that this approach keeps resulting in the same buildings. The construction industry is indeed aiming for individualisation, because ultimately it also offers a way to stand out amongst competitors.

Mr Buchli, what is your motivation as a robotics expert to look at construction processes?

JONAS BUCHLI – Many sectors of the economy have been turned inside out by digitalisation. This has affected, above all, areas where either data play a key role or where problems can be easily structured. In robotics, however, we now need to take the next step, which is to say that these technologies need to be brought to areas that are less structured, where more flexibility is needed and the machines need to react in a more timely fashion. The construction industry is an interesting starting point for this. A building site is certainly less well-structured than a factory, but still not quite as open as the world of service robots, for instance, which perform activities independently in the household. The potential in the construction industry is huge. But we will only be able to tap it if we solve complex robotics problems. That's an interesting challenge for me as a researcher.

"Today we can produce structures at a level of precision that a human cannot achieve."

JONAS BUCHLI

What has it been like to work with architects?

BUCHLI – When working with architects, the challenges and possibilities are entirely different than when "only" collaborating with engineers. I am learning an awful lot and am facing an entirely new perspective. What has surprised me is how pragmatic their approach is to using technologies and how target-driven their work is.

What has been implemented to date?

KOHLER – We're currently still at an early stage of research, although some companies have already taken specific steps towards digital fabrication. It will take a great deal of time until the new production processes have become ingrained and until the experiences have been integrated along the entire production chain. In tile and timber construction, we have seen that implementation will take at least six to ten years. When applied across the entire construction industry, these changes will take several decades. What excites me is the question of what we will gain from these technologies in terms of quality in architecture and in the construction processes, and what benefits they will bring for Switzerland.

HALTER – In practice, digital fabrication is certainly a known concept today. In timber construction, in particular, a lot is already being done. The fact that these technologies are not yet broadly applied is not so much a matter

PIONEERING WORK IN FLÄSCH

One of the first buildings in which digital fabrication was applied is the Gantenbein vineyard in Fläsch, Graubünden. In 2006 an industrial robot assembled bricks in accordance with a pre-programmed pattern at ETH Zurich under the supervision of architecture professors Matthias Kohler and Fabio Gramazio. The facade elements this process created were mounted to the building shell on-site. The bricks were slightly twisted towards one another, and the resulting openings reveal a pattern of oversized grapes on the facade, depending on the light and shade.

Built by robots, appreciated by wine enthusiasts

Picture credits: Ralph Feiner/Gramazio Kohler Architects

of possibilities: the problem is that we can only produce digitally if the data are available in a corresponding form. In this area, our industry is simply underdeveloped. There is no integral process from drafting to production through to operation. If we were to start by handling the data correctly during the planning process, implementation would be far easier. We actually have all tools at our disposal already. But our industry is still not able to use these tools.

Why is that?

HALTER – First, this has to do with the fact that we still think in a very subsection-specific way. In other words, we don't understand the building as an overall system. Second, we keep interrupting the planning process because we transfer data from one place to another. And third, the construction industry is organised in a highly commercial and work-sharing manner. The production of a car is a unified procedure; that's not the case for buildings. But construction is not more complex than car manufacture – we are simply aligned in such a way that it becomes more complicated. That's why processes are still very antiquated on building sites. But that is also an opportunity, of course, in particular for the design process. What's important to us is that digital fabrication results in quality improvements and ultimately also generates commercial benefits.

BUCHLI – The entire development will likely happen in a similar way as in computer technology. When we had the first computers on our desks, processes were hardly productive yet. But there were early adopters, who were thinking ahead. Only now, after many years, are computers really productive for normal users. We will undergo the same development in the construction industry. However, the problem is far more complex here, which is why the time frames will be longer. We won't be looking back in two or three years saying whether it has worked or not.

Where do you expect to see the first steps?

BUCHLI – What will likely become established in the near future are transport applications as well as certain precision applications. Today, we can produce structures at a level of precision that a human cannot achieve, at least not within the same period of time and working under the same conditions that robots do. However, if we want to bring these things to building sites, we need to increasingly include information from the building in the planning process. This was a directed process in the past: first plan, then execute. What we need now is to close the circle.

KOHLER – The crucial question is, of course, how this vision is implemented. Up to this point, architecture has mainly focused on the mental work. The idea was to develop a sophisticated planning software that integrates everything. This still largely works in planning today. However, where the matter becomes physical, the processes mostly remain conventional. We are now changing our perspective and looking for solutions that can be integrated retroactively, in other words from execution to drafting. I'm convinced that this approach will make it far easier for the construction industry to initiate a sustainable transformation from within.

Do you share this view?

HALTER – A lot speaks for this approach. The development is driven strongly by architects who focus on the end product and who work with components and materials that can only be implemented in a digital process. For instance, there are facades that can only be planned and produced on a data-driven basis. It will also be exciting to see what influence 3D printers will have. This is precisely the point: we look at what options we have in production and go back to the draft with this as our vantage point until both ends meet.

KOHLER – 3D printing is a very interesting catchword: 3D printers cannot simply be applied to architecture, although it is often presented this way. In principle, additive processes are interesting for us, of course. This has to do with the fact that good architecture is based on the artistic assembling of ›

OFFICE BUILDING AS RESEARCH LABORATORY

For the new Arch_Tec_Lab building on the ETH Zurich Hönggerberg campus, the Chair of Architecture and Digital Fabrication is planning a new kind of roof construction made from small wood elements. The project displays the potential of linking digital production techniques with sustainable and locally available building materials such as wood. The construction consists of more than 45,000 individual elements that are woven together to create a rolling wooden roof. The building will be ready for occupation in autumn 2016.

Roof construction as an area of research

Picture credits: Gramazio Kohler Research, ETH Zurich

elements to create rooms that are larger than the machines that build them. This is where 3D printing comes in: how do we find the structuring strategies in architecture that are based on digital technologies, but nevertheless take into account the requirements and economy of architecture? For instance, it makes little sense to print an entire building. Due to the resolution at which the printer works, the construction process takes a very long time and the material is also very expensive. However, if larger construction elements are used, a construction-aligned resolution can be achieved.

Can you elaborate a little on this?
KOHLER – I am speaking about new digital material systems, for instance: suddenly it's possible to handle a building material in an entirely different way thanks to digital technologies. It is very possible that this will result in developmental leaps. We also need to consider the ecological aspects: today, concrete walls are designed in such a way that they withstand the worst load scenario. These walls are built with a straight mould system. This results in about one third of the concrete not actually being needed from a statics perspective. If we use systems that don't need moulding, there are direct consequences for our handling of material resources. If the construction culture develops in this direction, we will thereby also be able to create added value in this area with the use of digital fabrication. Our research projects allow us to generate knowledge which Swiss companies will be able to use internationally. We would be delighted if the industry were to pick up on these stimuli and if our projects were to result in interesting collaborations.

What effects do these developments have for the people involved in the actual construction process?
HALTER – It's becoming increasing difficult to find the experts required. For that reason, we need to try to support the processes on building sites in terms of information technology in such a way that the required skills are more limited. This objective is also driven by commercial considerations, because the individual worker is becoming increasingly expensive.

What do you think of the roll-out of the new MAS Digital Fabrication programme at ETH Zurich, which is starting for the first time this year?
HALTER – No question: we need a programme like this. Because the development we have just been discussing can only happen if we also make changes to education. We need people who can handle these types of technologies. We are consistently initiating innovations, but are also noticing that people are out of their depth in practice, because they are faced with something that they don't know. A planner doesn't see why he should do something differently, because he doesn't get paid more but he does have to take on more risk. If he has no inherent drive to try a different approach for a change, and cannot even know the opportunities, then he simply won't do it. That's understandable. ○

"We need people who can handle these types of technologies."

BALZ HALTER

New Master's programme in architecture and digital fabrication

The MAS ETH in Architecture and Digital Fabrication is an interdisciplinary further training programme from the National Centre of Competence in Research (NCCR) Digital Fabrication at ETH Zurich. The focus is on methods and techniques of digital fabrication and their meaning for the architecture of the future. The NCCR Digital Fabrication is an ambitious research initiative that combines top research in the areas of architecture, engineering and robotics as well as material and computer sciences. As the central education platform of the NCCR, the programme is located at the heart of the latest research findings. The NCCR's unique robotic production plants will offer students the opportunity to research digital design and construction processes and implement them directly in large-scale prototypes.

The MAS ETH in Architecture and Digital Fabrication is designed as a 12-month full-time programme aimed at university graduates with proven design skills. The MAS will be supervised by the Gramazio Kohler research professorship at ETH Zurich. The programme is scheduled to begin on 14 September 2015. Applications can be submitted online until 30 April 2015.
→ www.dfab.ch/mas