Industry 4.0 on construction sites?

Robotics in construction

Construction Site 4.0 – sounds very promising. Yet in Germany and beyond, we are only just starting out with the fourth industrial revolution on construction sites. That's because, despite the digitalization of planning processes, construction methods have changed very little since the middle of the last century. Although there has been movement in planning and construction, optimized construction processes and digitalized construction site workflows will continue to differ greatly from industrial production in the future: Industrial production cannot simply be transferred 1:1 to the construction process. So, what might digitalized construction production look like, what special requirements will apply for using robots at the construction site, and what types of robots are there already? And what might and must a construction site look like for it to make sense to use them there and for it to be economically viable?

The construction industry is facing its biggest challenge in decades. Unlike other sectors in Germany, construction failed to boost its productivity significantly in the last 30 years despite an increase in construction activity in the past years. At the same time, there has been a noticeable demographic shift in the construction job market with stagnating employment figures. The building trade is already having great difficulty attracting young people to train in one of the construction professions; the number of new trainees can no longer compensate for the losses due to workers retiring or moving to other jobs. There is therefore no alternative to sustainable and productivity-boosting improvement to construction processes.

Digitalizing construction production – robotics at the construction site

One solution for the impending shortage of skilled workers comes in the form of digital technologies in the field of Industry 4.0. – for example, by boosting productivity in construction production through the use of more or less intelligent robots. Production robots or smart tools are already used in the prefabrication of construction products. But what should robots that can be used at the construction site look like?

Since construction sites and construction production vary greatly, the use of robots is much more difficult than in industrial production, and the complexity of the demands on their performance is accordingly high. Even erecting simple construction elements (such as masonry or a reinforced steel wall) requires a large number of completely different work steps. At the same time, construction sites themselves are a multifaceted and constantly changing work environment. Both this chaotic environment and the complexity of construction tasks make it far more difficult to use robots. Unlike the processing industry, where the mobility and

intelligence of robots hardly plays a role, the robots used at the construction site need a high level of flexibility in order to be able to adapt to the work progress. Furthermore, a certain level of intelligence and mobility is necessary for them to be able to respond to changing environments. Solutions also need to be found for the safety of the human workforce so that separate, safe and parallel deployment of robots and construction workers can be ensured at the construction site.

These new demands led to a paradigm shift in robot design. The most recent developments center on “soft” robots which, unlike their “hard” predecessors from industrial production, are suited to the great variety of tasks at the construction site. New, more powerful software and highly advanced sensor technology in the field of image recognition, resistance sensors or acceleration measurement are used in their programming. Thermal imaging cameras, laser scanners and gradiometers are also used for robot-assisted quality control. Research is already focusing on a second generation of robots whose flexible components afford them human-like levels of flexibility and performance and enable them to move autonomously even on uneven terrain.

Mobile robot systems

Mobile robots that can manufacture masonry on floor slabs are already available for masonry construction. The systems, so far only tested in pilot applications, still need to be recalibrated on each floor of the building. “Hadrian X” from the Australian company Fastbrick Robotics has already been used to construct buildings, and laid 26 square meters of bricks per hour. However, it is currently uncertain whether this is possible under German conditions, since the 30-meter-long robotic arm and a heavy substructure make Hadrian X difficult to position.
But there are much more compact alternatives. Its smaller robot colleague “SAM 100” from Construction Robotics has a mobile platform and can make straight walls with its shorter robotic arm, although it currently doesn’t yet work with the high-performance bricks we are familiar with. “Cable robots” offer a more holistic and promising solution. They can be moved extremely flexibly back and forth in three dimensions on a boom gantry, and pick up, move and lay bricks. Their use at the construction site is currently being researched at the Chair of Mechatronics at the University of Duisburg-Essen, among others.

The most advanced in terms of development is 3D concrete printing technology, a fully automated and additive manufacturing process. At one meter per second, the “BOD2” modular concrete printer is currently the fastest portal printer in the world. BOD2 only needs to be calibrated once and can move to any position within a framework structure. In Germany, the company Peri has already printed its first projects using the construction printer from Cobod.

Another smart system comes from Switzerland. The “InSitu Fabrikator (IF)” from ETH Zürich is an context-aware construction robot for fabricating construction elements directly at the construction site and can independently manufacture concrete moldings and walls using “Mesh Mould” technology. This allows it to produce complex geometries without the need for formwork. Thanks to its advanced sensor and control system, it can navigate automatically, locate its place of use independently, and respond to fabrication tolerances.

In addition to stationary or portable systems, development is also pushing forward in the field of humanoid robotics. The “HRP-5P” from the Japanese National Institute of Advanced Industrial Science and Technology (AIST), for example, is a humanoid robot. As a multitasking robot, it is designed to be able to complete tasks like a human; it can deal with several work steps independently, and can also be used in confined spaces. Other companies developing robotics such as Fortis and Daewoo are taking a different approach and working with wearable exoskeletons that can be integrated into the construction process without any difficulty. They are mostly worn directly on the body and increase the performance of the human wearing them, helping them to lift heavy loads without damage to their health.

Robot-oriented design or Construction Site 4.0?

Fully or partially automated construction sites like those we see in Asia are still hard to imagine in Germany and Europe. Nor do we expect an extreme standardization of buildings and construction elements here in the next few years to optimize the efficient use of robots, along the lines of robot-oriented design. Nevertheless, it can be assumed that robots will greatly support work at the construction site in the near future in repetitive and physically taxing activities, thus helping to make the construction process more flexible and optimize productivity. However, that requires the entire planning and construction site logistics to be structured in such a way that robots at the construction site can also really be used in an effective and targeted manner.

The digitalization of all processes across all phases of construction, from the shell to the finishing work, is a significant step toward the Construction Site 4.0. This digitalization must cover the entire value chain and include all the planning, production, ordering, supply and assembly processes, as well as the business processes. In addition to the planning through to the prefabrication of material supplies, this also applies to the work preparation, all material flows, machine movements, and equipment inventory at the construction site. It will change construction site organization completely and reduce the workload for for the construction workers and skilled contractors on site in a new and previously unforeseeable way.