

Pioneering Spirit and Teamwork The Digitalization and Automation of Construction Sites

At a moderately steady pace, an outlet chute attached to a crane track moves around the floor plan of a house leaving behind a thin strip of fresh concrete as it goes. Once it has completed a full lap of the floor plan, it repeats the whole process leaving a new layer on top of the first one. It goes round and round like this until the entire first floor has been completed, which is around 25 hours after it produced the first layer. No more than two to three experts are on site overseeing the process. Welcome to the 3D-printed house of the present. Even larger dimensions are expected to be possible for 3D-printed houses of the future.

Rupp Gebäudedruck, a company located in Swabia, Bavaria, is already using this new 3D printing technology which lays and shapes concrete without using any formwork. It takes an average of just 48 hours using this process to print a detached house, including the channels for the water pipes and electrical wires. Owner Fabian Rupp believes that it will soon be possible to mass produce 3D-printed buildings: “It has gradually become clear to us that there truly is a future for this technology.” And he could well be right as the first German 3D-printed house was produced in 2021 in Beckum, North Rhine-Westphalia, based on the plans of the engineering and architecture firm Mense-Korte Ingenieure +Architekten.

The 3D printing of buildings is just one of many pioneering technologies that are revolutionizing construction sites thanks to digitalization and automation. However, it is not just the manufacturing and assembly side of things that needs to be digitalized but also tools, machinery, fleets of construction site vehicles and business processes too. Digitalized construction processes optimize and standardize work processes and increase productivity. What’s more, they also prevent data redundancies, errors, unnecessary transit and mountains of paper. This means that planning and cost security can be guaranteed, materials and resources can be saved, and an extremely high level of detail and precision can be achieved as early on as the planning stage. Digitalized construction processes also make it easier and in some cases possible in the first place to achieve creative designs, such as for example those involving highly complex shapes. “Future Tree” created by Basler & Hofmann as an extension to its own building in Esslingen, Switzerland, is a prime example of best practice. The project team took new methods created in the laboratory and put them into practice in order to create the parametric design. Aleksandra Apolinarska, a postdoctoral researcher at Gramazio Kohler Research, ETH Zurich, explains: “The pilot project shows that the digital planning methods and digital production also work in practice.”

Digitalized construction sites still sometimes constitute the large minority as the construction industry is one of the last industries to have still only achieved a very low degree of digitalization. Less than 6% of all construction companies use digital planning tools other than digital drawings. The construction industry is on the cusp of a transformation being driven by the increase in available digitalization and automation technologies.

Digital Planning Is Essential

The planning method “BIM” needs to be introduced for digital construction sites to work. The abbreviation stands for “building information modeling” whereby an entire building is first digitally planned and created on the basis of 3D models before it is actually manufactured in reality. In addition to classic 3D CAD plans, from design right through to execution and assembly plans, it also covers costs, quantities and deadlines. If changes are made to one aspect (parameters) then all other aspects are also automatically updated. The so-called “digital twin” enables users to compare planning data with real data.

Digital Manufacturing, Assembly and Tools

Digital manufacturing includes additive processes such as the 3D printing of buildings. Computer-integrated manufacturing (CIM) will be standard in the future. It is also likely that digitalized processes will be used throughout the entire value chain. One such example is the process of site measuring using 3D laser scanners, whereby surveying equipment is fed with BIM files which are imported into a satellite-based surveying rod (e.g. GPS) and employees on site survey buildings or the terrain using a tablet. This instrument particularly lends itself to reconstruction projects. Drones are equally important digital tools on construction sites. They digitally monitor the construction and act as documentation and archiving tools for site managers. Some companies use them for project marketing. VR and AR headsets, which depict reality virtually, are also suitable for such purposes. However, they can do even more than this: they enable drivers of construction vehicles or foremen on the construction site to compare the plans with reality.

Digital Machinery and Construction Vehicles

Digitalization is changing the construction machinery industry, with driverless machines being the most extreme example. Satellite-based technologies such as GPS are already playing a key role, in particular in terms of controlling machines or construction vehicles for conducting accurate excavation, digging or leveling work. The technology provides the digital interface to the surveying equipment and planning data. Drivers receive all information regarding the actual state of the work vs the desired end state of the work via a display or a VR headset. Whilst the work is being carried out, information regarding the current state of affairs flows back into the BIM-based planning system. However, a lot of this still seems like a far-off vision of the future. Peter Guttenberger, who is responsible for construction machinery at Max Bögl, says: “The transition to Construction Site 4.0 still seems quite tentative. We need to try to get all those involved in the construction process on track. Progress is still not being made at the same rate everywhere. However, we need to ensure that all project participants are on the same page in order to be able to really utilize the benefits.”

Tracking and Tracing of Building Materials and Construction Equipment

It still takes time for many analog construction sites to identify and locate building components and building materials. Thanks to the Internet of Things (IoT), physical objects such as construction machines, building components and building materials can be connected to the Internet. As a result, information regarding the execution status on site can be automatically generated and exchanged. Digital construction sites can save valuable time by using RFID or Bluetooth systems. These technologies also enable more efficient management and real-time tracking of delivery, storage and installation processes. Integrated systems take care of all fleet management at large construction companies – from the point at which a contract is accepted right through to when the final invoices are issued and paid. A research project being conducted by the Chair of Materials Handling, Material Flow, Logistics at the Technical University of Munich is focusing on the tracking and tracing

of building materials and construction equipment. A simulation compares real data with planning data and transfers the information to the construction site management system and on to the driver. Project member and engineer Stephan Kessler highlights a key benefit: "It enables us to increase construction-related efficiency and sustainability."

Digital Communication and Business Processes

Communication between project team members is extremely important for digital construction sites. The aim is to ensure that all those involved in the construction project work together efficiently when carrying out complex construction tasks. Digital solutions are used and stored in a central database. The trend is for Internet-based cloud solutions as they enable mobile working. Digital exchange platforms connect all project members from all trades via interface-based modules such as a daily construction log, an acceptance report, task and defect management or general reports and records. They also include communication platforms that replace traditional email inboxes.

Challenges Facing the Construction Industry

The construction industry of the future needs to overcome a wide range of different challenges. First and foremost there is a need to reduce the construction industry's ecological footprint. Construction waste needs to be minimized and smart cities need to be created, and part of this includes ensuring that reconstruction projects are as minimally invasive as possible. At the same time, an approach that takes the demographic structure into account needs to be incorporated. What's more, there is a lack of trained professionals and fresh young talent in the construction industry. Rupp Gebäudedruck, for example, has been making the best out of this difficult situation by developing 3D concrete printing. On the one hand, the company is saving on the cost of labor by automating and, on the other hand, the impressive level of innovation involved is attracting new employees. A confident Fabian Rupp says: "Thanks to this innovative technology, we can make the masonry profession more attractive again."

Conclusion

Digital processes are therefore absolutely essential for the construction industry to be able to meet its challenges. However, growing demand for new, digital construction processes must also be matched with political will and political backing as there is still a lack of standards for practical implementation, and the roll-out of broadband Internet is progressing far too slowly. However, back in 2018, North Rhine-Westphalia became the first German state to agree in the coalition agreement to use the opportunities offered by digitalization in construction policy. From a technical point of view, there are also still a lot of intermediate steps that need to be taken. Time and again, the software used does not meet all the requirements and there is often a lack of viable interface solutions. All those involved in the construction process therefore need to seize the opportunities offered by digitalization. There needs to be a pioneering spirit and a willingness for different disciplines to work together. This applies to those involved in research and industry just as much as it does to architects, planners, construction companies and craft workshops. Everyone needs to change the way they think and put their knowledge into action in order to also ensure social acceptability.

Quote sources:

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Quote from Aleksandra Apolinarska/Gramazio Kohler Research, ETH Zurich/Future Tree

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