Univ.-Prof. Dr.-techn.
Sigrid Brell-Cokcan

Production Engineering Cluster
Campus Boulevard 30
52074 Aachen
GERMANY
Phone: +49 241 80 95005

office@ip.rwth-aachen.de

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ROBETON

Robot assisted demolition of concrete walls

Climate change and rising raw material prices require to rethink the handling of existing material resources and building structures. By digitally transforming a demolition machine into a semi-automated robot, a new sustainable process for safe, controlled deconstruction is being developed at the Chair of Individualized Production at RWTH Aachen University. In the research project ROBETON, we digitalize the deconstruction process enabling the reuse of concrete building components as a source of secondary building products for further use in construction and refurbishment.

Construction is one of the most critical economic sectors for climate change, accounting for over 39% of global CO_2 emissions and primary energy consumption. The production of construction materials such as steel, glass, and cement is responsible for over 11% of total CO_2 emissions worldwide[1] . With a consumption of over 530 million tonnes of raw materials, construction is a main contributor to global resource depletion. The CO_2 emissions of cement production for construction is over 3.76 billion tonnes, 2.5 times higher than emissions created by global road traffic.

Current buildings and infrastructure account for 28 billion tonnes of existing building material. This is a significant man-made store of resources that has the potential for reuse as new building components[2]. Buildings are currently demolished after reaching their specified lifespan, with more than 77% of potential building materials ending up as filling material in roads and landfills. The reuse of secondary building products reduces CO_2 emissions, however current deconstruction processes do not enable this possibility. The Robeton project aims to bridge this gap by automating the deconstruction process.

In response to increasing climate change and rising material shortages, the construction sector demands innovation for more sustainable solutions, controlled deconstruction and for the recovery of building components as a future source of secondary building products.

In the ROBETON research project at RWTH Aachen University, research and development for the adaptation of a robust demolition machine to a digitally controlled deconstruction robot is carried out, enabling the reuse of concrete components.

Several requirements must be taken into account to transform manual demolition into automated deconstruction. Numerous environmental factors such as weather conditions, dust and debris must all be accounted for. Unpredictable material properties and deviations between digital plans, if available, and physical sites further complicate the design of robust and reliable robotic systems.

[1] https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Klimaschutz_in_der_Beton-_und_Zementindustrie_WEB.pdf

[2] https://www.umweltbundesamt.de/daten/ressourcen-abfall/verwertung-entsorgung-ausgewaehlter-abfallarten/bauabfaelle#verwertung-von-bau-und-abbruchabfallen

The BROKK machine is an industry leader in demolition, robust and tested for over 40 years. The ROBETON project develops this manual machine into an intelligent robot through the digitalization of system control, transforming demolition into a controlled process of deconstruction for material reuse.

Building Information Modelling (BIM) models of the construction planning are connected to the robot control via a newly developed user interface. In addition, the demolition robot is supported by a second mobile robot for environment detection and component recognition. Sensor data is utilized for collision-free path planning and execution of the controlled deconstruction.

For the BROKK machine to execute a precise automated movement, complex coordination of several hydraulic axes is required. This challenges traditional kinematic robot path planning. The joint movements are not individually controlled by electric motors but instead are driven by hydraulic actuators incapable of synchronized preplanning of axis movements. To overcome this challenge, the ROBETON research project equips the BROKK with sensors and machine learning for control process automation.

To transform recycling into controlled material harvest and reuse, the ROBETON research project creates a novel automated end effector from a HITLTI saw. The movements of the automated BROKK axis and Hilti saw are precisely pre-planned and adapted to construction site requirements before execution. The deconstruction robot then cuts out the components in a minimally invasive manner with the resulting material ready for reuse. The cut-out components are then integrated into new projects, saving material and CO_2 emissions instead of ending up as waste in a landfill.

The automated manual equipment within the ROBETON project can be transferred to further construction processes such as drilling, material handling or refurbishment. This enables the research and development of ROBETON research project to positively impact the future of construction in ways that reach beyond this initial use case.

"In addition to the economic benefits of digitally increasing the efficiency of construction machinery and reusing the extracted concrete building parts, the aim is to increase acceptance in the construction industry by digitally enhancing an already existing construction machinery technology while keeping the product price the same," explains Prof. Sigrid Brell-Cokcan.

Through the support of industrial partners and the testing of a first prototype on the reference construction site of RWTH Aachen University, the evaluation and validation is ensured so that the functionality of the procedure under real construction conditions is verified.

The ROBETON research project also investigates the impact of construction automation and its potential improvements in occupational safety, as well as the reduction of environmental impact such as dust and noise emissions.

The ROBETON research project´s deconstruction process is minimally invasive, which especially benefits urban areas. As an extension to BIM, future deconstruction processes will integrate digital deconstruction documentation to inform planning of concrete material reuse. The ROBETON innovations in deconstruction robots adds value through cost reduction, material reuse, robotic transportation, digitization of information and quality assurance.

This research project is intended to reduce the resource consumption of concrete and the associated CO2 emissions in the long term. The value of secondary building products can be economically tapped for innovative reuse of material in construction and renovation " emphasizes Prof. Brell-Cokcan.

Press Contact:

RWTH Aachen University
Individualized Production in Architecture
Univ. Prof. Dr. techn. Sigrid Brell-Cokcan
Production Engineering Cluster
Campus Boulvard 30
52074 Aachen
Phone: +49 241 80 95005
office@ip.rwth-aachen.de

The project partners involved are:

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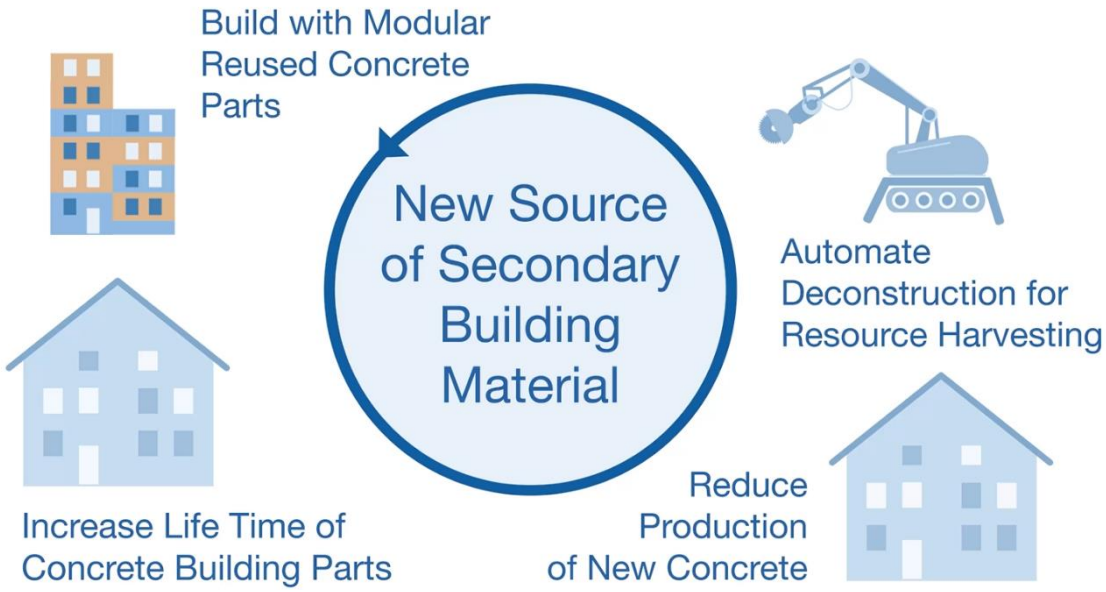

Figure 1: Concrete building components as a source of secondary building products

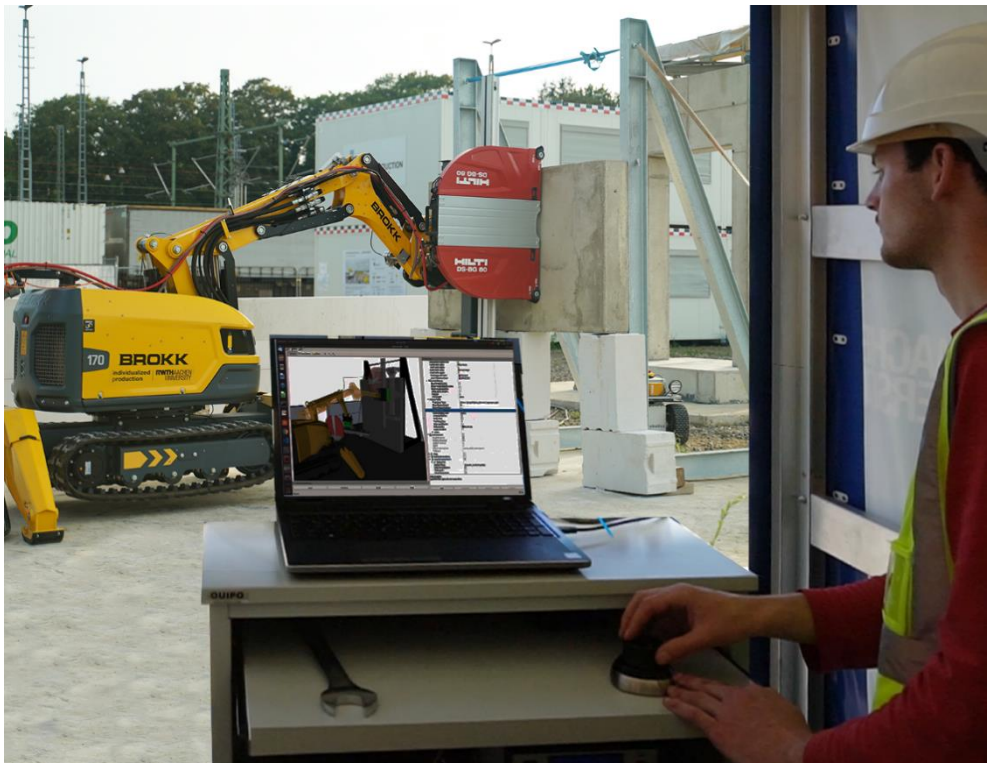

Figure 2: Simulation, planning and execution of the machine path from a safe distance

Figure 3: Construction site set-up BROKK with wall saw