Fakultät für Bauingenieurwesen und Umwelttechnik

Technology
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TH Köln

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Reuse of excavated material during mechanized tunneling with the help of AI-based innovation MEGA

When a tunnel is being constructed, over 200 tons of material can be excavated per hour, which is often disposed of in landfills. The "Muck measuring system for EPB tunnel borinG machines based on AI" (MEGA) innovation allows for an AI-based analysis of the material excavated during operation and thus for a better and more sustainable use of these valuable raw materials. The system was developed within the REMATCH research project conducted by TH Köln and its partners STUVA and Herrenknecht AG.

"Excavated material from tunnel construction can be used in a variety of ways, depending on its nature. For example, it might be used as a roadbed or concrete aggregate. This, however, requires the material to be separated and sorted by type as accurately as possible at the construction site. To make this possible, we have developed an AI-based system that will determine the geotechnical parameters relevant for sorting in real time," explains Prof. Dr. Christoph Budach from the Faculty of Civil Engineering and Environmental Technology at TH Köln.

New instruments measure forces in the material flow

The relevant parameters that influence the stability of soils to be installed include, among other things, the so-called slump, which describes the processability of the mined soils, the shear strength and the water content. "These parameters cannot be determined continuously or only with great difficulty with the usual methods applied when operating an EPB shield machine, a frequently

used type of tunnel boring machine," says Dr. Pierre Müller, research associate at the Department of Geotechnics and Tunneling at TH Köln.
"We have therefore developed the new MEGA measuring system, which is installed on the conveyor belt on the tunnel boring machine. The excavated material passes a spherical pendulum and a plow, where impulses on the two instruments are measured. Depending on the properties of the material, the recorded force curves vary over time," says Dr. Christian Thienert of STUVA. "An artificial intelligence now links force curves and simultaneously determined index values such as shear strength and slump. Thus, it is possible to determine these properties, which are crucial for the utilization of tunnel excavation material from fine- and mixed-grained soils, in real time and to classify the excavated material while it is still on the conveyor belt, so that appropriate sorting can be carried out," explains André Heim of Herrenknecht AG.

Tests under real-life conditions

In order to obtain a valid database to train the artificial intelligence, the project team first tested various material samples on a circular conveyor belt with a two-meter diameter at the premises of project partner STUVA e.V. in Cologne. To better reflect the actual conditions on a tunnel boring machine, project partner Herrenknecht AG built a 50-meter-long test conveyor belt on a scale of 1:1 at its headquarters in Schwanau, Baden-Württemberg. There, MEGA was used to examine and classify many different samples under real-life conditions. In addition, the prototype system was put to the test in a real-life situation by being placed over the conveyor belt of an EPB machine used in a tunnel construction project in Europe.
"In this project, we have laid very good foundations to adequately determine selected geotechnical parameters of the material excavated and thus determine its recycling potential. Further research is already in the pipeline," says Budach.

About the project

The results were achieved within the research project "REMATCH – REsource efficient tunnelling based on real-time excavation MATerial CHaracterization", which was funded by the German Federal Ministry of Education and Research and the French National Agency for Research from 2021 to 2024. The Research Association for Underground Transportation (STUVA e.V.) was the German project manager. The other partners alongside TH Köln were the tunnel boring machine manufacturer Herrenknecht AG and, on the French side, the planning and consulting company Arcadis and LIRIS, the Laboratory of Image Informatics and Information Systems of the University of Lyon, as well as the associated partners DB Netz AG, the French Center for Tunnel Studies (Centre d'Études des Tunnels) and the public builder Tunnel Euralpin Lyon-Turin.

Caption

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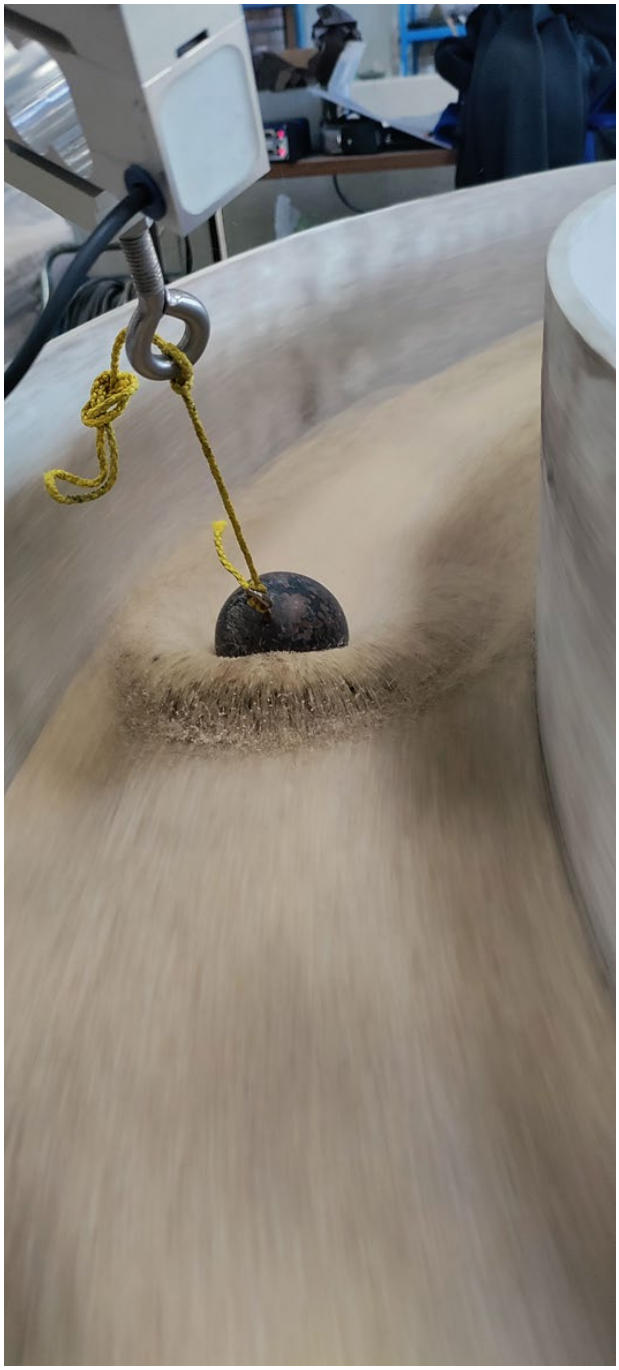
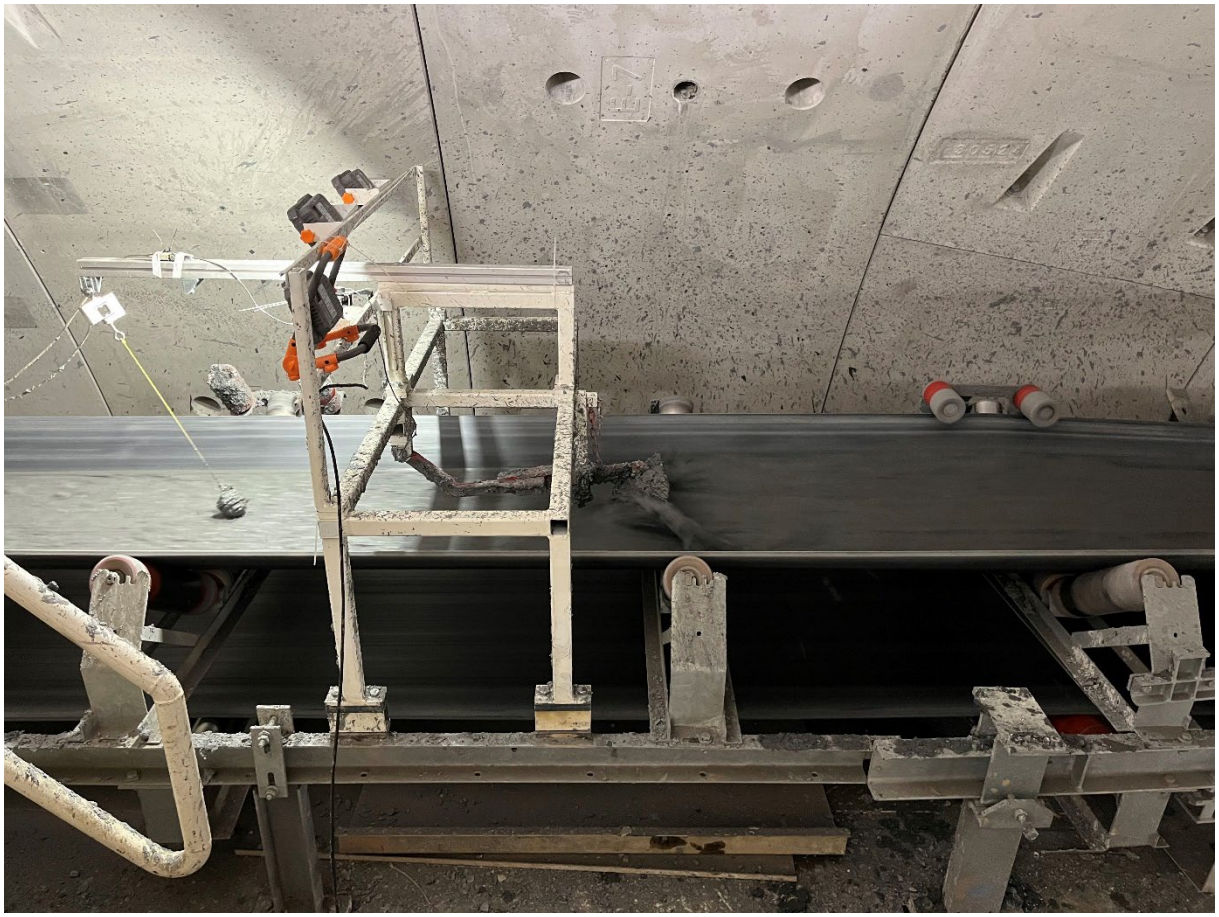
1
View into an earth pressure shield machine: A conveyor belt takes away the excavated material at high speed. (Photo: Herrenknecht AG)

2
The MEGA measuring system consists, among other things, of a spherical pendulum, a plow, cameras and lighting equipment mounted above the running conveyor belt (Photo: TH Köln)



3
Different soils mined exert different forces and impulses on the measuring instruments. (Photo: STUVA e.V.)

4
The new system was tested, inter alia, on a 50-meter-long conveyor belt at Herrenknecht AG in Schwanau. (Photo: Herrenknecht AG)



5
The MEGA measurement system in use on an earth pressure shield machine.
(Photo: TH Köln)