

## Karlsruhe light rail tunnel project

# HIGHER ADVANCE RATE WITH CUTTER WHEEL

## KEMROC cutter wheel replaces hydraulic hammer

At the Karlsruhe light rail tunnel construction project, a 250-metre long section had to be excavated using standard tunneling methods. Due to unfavorable geology and the proximity of buildings, the engineers at BeMo Tunnelling could not use an excavator mounted breaker to remove the temporary concrete support structures in the crown section. They decided to rent a low vibration cutter wheel from KEMROC. Not only did it resolve the vibration issues but it also proved to be a huge time-saver.

The city of Karlsruhe is changing her appearance. They plan to use a combination of a light rail tunnel and a road tunnel to relieve congestion in the central downtown area. The Stadtbahntunnel consortium consisting of BeMo Tunnelling GmbH and FCC are responsible for the structural work in the work lot Stadtbahntunnel. When completed in 2018, there will be a tram tunnel running below the west to east flowing Kaiserstrasse with a spur running to the south from Marktplatz in the center of the city.

The tunneling engineers at BeMo work under difficult geological conditions: the Karlsruhe substrate consists of quaternary gravels and sands with deposits of war debris. Due to the nearby Rhine river, the water table is approximately 4 m below the surface. That's why a 250 m-long section of the southern junction must be driven using compressed air tunneling methods. The tunnel site has an overpressure of up to 1.25 bar to prevent ground water entry. The complex ground conditions have had significant implications to the cost of the tunnel.

## Buildings close to the tunnel

When the top heading was excavated from south to north, the crown was supported after each meter advance using sprayed concrete and steel reinforcement. For structural reasons, a temporary, lightly reinforced concrete base layer was also built as additional support. This had to be removed while driving the bottom heading from north to south. Under normal circumstances, the concrete would have been removed using a breaker on a 30 ton excavator but this was not possible for two reasons. In contrast to most metro tunnels, this tunnel was relatively close to the surface and the space between the tunnel and the foundations of buildings overhead was only a few meters in some locations. These buildings



A view of Karl-Friedrich-Strasse in Karlsruhe. The southern spur of the Stadtbahntunnel runs below this street creating the need for BeMo engineers to use special tunneling methods due to the immediate proximity of surrounding buildings.



BeMo used a KEMROC cutter wheel to separate the floor of the crown in the South Branch of the light rail tunnel to eliminate noise and vibration when using a breaker.

Photo: BeMo Tunnelling

included hotels, retail units and apartments and the residents would have suffered from the noise and vibration of a breaker working so close on a three-shift working cycle. The second reason was the possibility that the blow energy used to break the concrete could damage the overburden resulting in air escaping from the compressed air zone with increased costs to maintain pressure.

More conventional methods to remove the concrete crown section such as diamond saws or high-pressure water jets were ruled out due to the start-up time required. Specialist subcontractors would have to be trained to work in high-pressure environments before being able to start work. After all methods were considered, the best option was to use an excavator attachment to remove the temporary, 50 cm thick, reinforced concrete in the transition zone between the crown and bottom heading. From the various options available, it was decided to use a cutter wheel from KEMROC. The shape of the wheel, with its tungsten carbide tipped cutters, gave the option of removing large amounts of concrete without producing large quantities of cut material by cutting deep slots in a short amount of time. The range of DMW wheel cutters (Erwetor) give options for depths to 1,200 mm in rock or concrete with compressive strengths up to 100 MPa. There are 4 models in the range which can be used on excavators from 14 to 60 ton operating weight. The model supplied for test on BeMo's 30 ton tunneling excavator was the Erwetor DMW 130\_600 with a wheel 130 mm wide and cutting depth 600 mm.

## Quick slot cutting in concrete

The cutter wheel was tested on site before the decision was taken to rent it. The test results were so positive that the contractor decided to use the cutter wheel to remove the concrete base layer along the full length of the tunnel. Three, sometimes four, longitudinal slots were cut along the entire length, parallel to the cutting slots along the sides of the tunnel. A truck, that was normally used to spray concrete, together with an extra hand lance were used to spray water on the cutter wheel to keep down dust. With a small number of blows from a hydraulic breaker, the rows of concrete left standing between the slots could be broken into sections approximately 2 x 2 m which were loaded quickly and easily onto trucks and transported out of the tunnel. Finally, the small sections of concrete remaining were broken up using a small breaker.

Robert Schweitzer, the BeMo Plant Manager located on site, valued the considerable time savings achieved through slotting the concrete with the cutter wheel. He said, "It would have taken much longer to break down the concrete using the breaker on its own. Reducing the amount of time required for these critical phases of the project is always a bonus and in this case, there was the added advantage that we could separate the concrete from the rock very easily for disposal purposes."



The KEMROC cutter wheel went through the 50 cm thick, reinforced concrete base in the crown section to the bedrock below.

Photo: BeMo Tunnelling



Developed to meet customer requirements, the 1,600 mm diameter cutting wheel of the DMW 130\_600 is fitted with a stabilizer shoe to reach a cutting depth of 500 mm.

Photo: BeMo Tunnelling

According to Robert Schweitzer, the BeMo operators felt comfortable with the KEMROC cutter wheel from the very beginning. As a result, they reached their main goal which was to drive the tunnel while keeping the noise and vibration generated using a breaker to an absolute minimum. In conclusion, he felt that the rapid removal of material from the job site using this approach was a bonus: "We have saved several days during the two months allocated to excavating the lower heading - and a day of operation on compressed air at our site costs at least as much as a mid-size car. Under similar operating conditions we would use this combination of equipment again." ■



Robert Schweitzer is the Plant Manager from BeMo Tunnelling GmbH responsible for equipment at the Stadtbahntunnel project in Karlsruhe.

#### **Publisher**

KEMROC Spezialmaschinen GmbH  
Jeremiasstr. 4  
36433 Leimbach  
Germany

Phone +49 3695 850 2550  
Fax +49 3695 850 2579  
E-Mail [info@kemroc.de](mailto:info@kemroc.de)

[www.kemroc.de](http://www.kemroc.de)

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